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The Individual at Urbana

THE ASAE has practically started a school of meeting efficiency in its continual efforts to improve its meetings. The forthcoming annual meeting at Urbana, and all who attend, will profit thereby.

There will be entertainment, and opportunity to learn by seeing as well as by hearing. But as one member has said, "It will not be a picnic, or a vacation, or a joy ride." He wants it to be "a business meeting from which I am going to come home loaded with good, sound, valuable information due to contacts and associations with men who are interested in the same things that interest me." And it will be that for every agricultural engineer who attends.

Simultaneous sessions of the four technical divisions will make a difficult schedule for those interested in the program of two or more divisions, but this has been agreed upon as the lesser evil. It is impossible to plan one series of events to meet the complete satisfaction of all who will attend. The arrangement most satisfactory to the largest number is a selection of sessions and activities. In this connection a word is in order as to how the individual can gain most by his attendance at the meeting.

When more than one session is being held simultaneously, the obvious choice for the individual is to attend the one of greatest interest to him. Free time for individual contacts is planned and copies of papers will be provided as far as possible, to enable him to catch up on sessions missed. Furthermore, for efficient discussion of problems of interest to small groups, round tables can be scheduled on short notice.

Planned sessions are simply the framework of the meeting, upon which the individual can build the superstructure largely to suit himself by active pursuit of his individual professional interests in the favorable environment provided.

Agricultural Engineering Terminology

DO agricultural engineers limit their field, usefulness, public acceptance, and even their own outlook with the common terms of their field? C. O. Reed has suggested the possibility.

Such words as tractors, machinery, and farm buildings, when used to indicate branches of agricultural engineering activity, suggest in themselves that agricultural engineers are primarily manipulators of units, he indicates. These words are the signboards of detailed means of accomplishing certain ends, which fail to picture the true broad functional field of agricultural engineering.

As an alternative he suggests identifying major areas of activity within the field in terms descriptive of general functions, such as powering, processing, sheltering, storing, and controlling water.

These are things to be accomplished. They do not specify or limit the agencies by which they shall be accomplished. Neither do they limit the public's nor the agricultural engineer's concept of his functions and field of activity. We enlist further thought on the proposition that agricultural engineering it not a limited accumulation of physical agencies; that it is definitely a natural grouping of major functions, and that it should be so indicated in its terminology.

Farm Steel Application Research

A FELLOWSHIP in agricultural engineering at Iowa State College, to conduct research leading to the proper and more economical specification and application of steel for farm use, was recently announced by Mr. T. M. Girdler, chairman of the board of Republic Steel Corporation, the sponsoring organization.

This is announced as the first move of a steel manufacturer to undertake research on the fellowship plan. It will supplement the pioneering step taken by the same company last year in establishing, within its organization, an agricultural engineering department to give its metallurgic and production departments an engineering interpretation of farm problems and opportunities, and to give farmers practical-use knowledge of the possibilities, characteristics, and limitations of steels available for farm applications.

No training nor environment could be more conducive to the contemplated research than that offered by a college agricultural engineering department. Agricultural engineers understand and appreciate the qualities of steels, and of the manner of their fabrication and use. They are in contact with farm-use problems, purposes, and materials. They know the characteristics of the farm products to be protected, of the conditions from which they are to be protected, and of the operations to be performed by materials on farms. They know where materials will meet corrosive conditions, fire hazards, soil and weather exposure, and unique biological requirements. They have identified and are continually identifying unknowns—blanks in the field of scientific knowledge needed to answer important agricultural engineering problems.

It is some of these blanks, in connection with farm uses of steels, that will be filled in by the research fellowship established. The hundreds of grades of steels, with characteristics varying almost infinitely between established limits as to hardness, brittleness, tensile strength, compression strength, corrosion resistance, ductility, malleability, bonding qualities, machineability, etc.; and the hundreds of combinations of farm operations to be done, conditions to be controlled, and cost limitations to be met by materials with properties within the range of those possessed by steels, provide an endless variety of application problems as subjects for research.

We expect such research to add to the range of farm operating possibilities; to the extent and economy of agriculture's service in producing foods and industrial raw materials. Our hats are off to the Republic Steel Corporation again for a farsighted contribution to agricultural progress.

Drought and Drainage

DURING this unusual drought period there has been much voicing of opposition to land drainage. This opposition, of course, comes from those who are not familiar with meteorology, and it is not the purpose of this article to condemn them. Engineers who have had training in meteorology, hydrology, or even a good course in high school physical geography, know that land drainage has had no effect upon rainfall in the past and will not have any effect upon rainfall in the future. We do know that the drainage of ponds and wet spots in cultivated farm land has all the advantages of the past, plus the increasingly important advantage of fitting fields for the use of modern machinery. Those who have lived through a few cycles of wet and dry weather, know that we will have wet years in the future as well as dry ones.

There will be plenty of tile drainage work done in the years ahead, and the agricultural engineer should be prepared to see that it is done correctly. We believe that there has been as much money wasted in the past years on improper tile drainage as on any other engineering job connected with agriculture.

It is our job to see that future drainage work is done right the first time. This means that the training of students in drainage engineering should not be neglected in our college agricultural engineering departments. Land drainage work has been definitely allotted to agricultural engineers, and we believe it is important to continue to train for it. In fact, we do not believe in calling it "water conservation." It will be vastly more important than water conservation over a long period of years. Furthermore, the principles of land drainage are also the fundamental principles of water conservation work.

The drainage of farm land does not necessarily include the drainage of lakes and swamps that are necessary to the propagation of wild life. On the contrary, field drainage into these bodies will serve to improve them for the purpose by increasing their natural drainage basin and helping to maintain them in extensive drought periods.

RALPH L. PATTY

Agricultural Engineering in the Animal Industries

DAIRYING is a superb example of an animal industry offering a field of opportunity for agricultural engineers. It is widely practiced and its products universally used. The aggregate volume and economic value are immense. Processing, packaging, and marketing by large plants is not primarily an agricultural engineering matter, and problems of handling milk after it reaches such plants have been engineered by engineers other than agricultural.

However, the perishability of milk and public interest in its sanitation, purity, and value as food and as a source of other food products, dictate a large measure of engineering control before the product can reach the care of engineers and engineered equipment in large milk plants and creameries. There is also the matter of product sanitation, processing, and packaging on the dairy farm which sells direct to the consumer. Some equipment not developed by agricultural engineers has been introduced, but its adaptation and application on farms are definitely matters for agricultural engineering assistance.

Not only the nature of the product, but the conditions of production call for agricultural engineering in the dairy industry. Housing, fencing, the handling of feed and other materials, and milking are factors materially influencing the unit cost of production.

A review of the contents of AGRICULTURAL ENGINEERING shows attention being given to dairying as an industry, and to its separate operations. But what of the other animal industries? In poultry, agricultural engineering attention seems to have been concentrated on chickens, and with them, on housing, lighting and irradiation, and brooding. Some scattered work is evident on incubation, water heaters, feeders, and refrigerated egg storage. In the hog raising industry there has been some work on housing, but little else. Other animal industries apparently remain practically untouched by agricultural engineers.

Probably no other animal industry provides so much opportunity for engineering as does dairying. But they all involve some engineering problems. It seems that here may be some neglected opportunities awaiting the attention of agricultural engineers.

Recognition from a Sociologist

A REVELATION of the extent to which agricultural engineering is penetrating the consciousness of leaders in related fields is shown in the paper Dr. Howard W. Odum presented at the recent farm chemurgic conference.

Dr. Odum is Kenan professor of sociology at the University of North Carolina, visiting professor of sociology at the University of Illinois, and director of the Institute for Research in Social Science. He said in part, "I venture to protest the common predictions that in the next periods of American development agriculture and rural life, the land and the people on it, must recede yet further and further into such dangerous ratios as to make American democracy impossible of attainment. I venture the assumption that the enduring equilibrium in American culture will not be found in less than a fourth of its people and their occupations in the rural-agricultural area, but more nearly a third; that not a sixth or a seventh of the national income will be derived from agriculture and allied work, but nearer a fifth. Such a premise still assumes urban development and the increase of technology. We know about the trend to cities; we know about too many farmers already; we know at present that many folk will not abide our country civilization. But we also assume new skills in land conservation and utilization, a nearer approximation to agricultural parity, the aid of agricultural engineering, the development of chemical service to agriculture, rural electrification and power development, the upraising of standards of housing, living, rural institutions; the function of agriculture as a great reserve economy in time of national depression, and the working out of national-regional and interregional balance and equilibrium."

However that may work out, such recognition of the social significance of progress in agricultural engineering, and of developments in which agricultural engineering is playing a large part, is evidence of the progress leading agricultural engineers are making in picturing the potentialities of their field to important leaders in related fields.

Agricultural Engineering and the New Frontiers

By Philip S. Rose

THIRTY years ago mass production was just getting started. The free homesteads were gone. Only three years before, J. J. Hill was telling the world of the impending scarcity of wheat. Land prices were rising. Foreign trade was expanding. The tractor was just beginning to to be talked about. America and the world were waking, throbbing with new hope, new ambition, new energy. We were living in the greatest age in the greatest country that the world had known. Democracy was triumphant. There was need of agricultural engineers.

There was need of more power and of mechanical efficiency in agriculture. We had to apply mass production to the farms. There was need of land reclamation, of irrigation; need for new and better machinery. There was a big job ahead, already laid out, waiting to be done. Everyone felt the stimulus of a rising tide in human affairs.

And how did the new society—the American Society of Agricultural Engineers—meet the challenge? Admirably, I think. The Society has done a great work. I believe I speak for all the charter members when I say you have fulfilled our highest ambitions and made our youthful dreams come true. I congratulate you.

But what of the future? What does the road ahead look like at the end of thirty years? Where do we go from here? This is a question that every human being and every human organization is compelled to ask itself at frequent intervals.

You agricultural engineers are interested in what is going on in agriculture. You are dependent upon agricultural developments, and are in the peculiar position of facing in two directions—toward agriculture and toward industry. You are a liaison society. Let me tell you of some of the new things that are going on in agriculture. Some of them may surprise you.

In my opinion agriculture is destined for greater changes in the next two decades than it has made in the past ten. We are beginning to have a really scientific agriculture. That is something new in the world. It started in a small way less than twenty years ago. It is in about the same state of technical development that our other industries were in at the beginning of the century. Today science is not tied up with pink ribbons in the neat little packages it came in thirty years ago. Your agricultural engineering problems today reach deep into electricity, into chemistry, into biology.

I'm rather pleased at the turn toward chemistry the Society has taken in the past two years. Chemistry is going to be increasingly important as the years go on. I think there is a good bit of day dreaming about how it will be the ultimate savior of agriculture, but dreams are permissible to men who test their theories as they proceed.

Also there are other fields you men will eventually be compelled to explore, that at first glance do not seem to lie within the engineer's orbit. I am thinking now of such things as photosynthesis, photoperiodism, plant genetics and animal genetics, applications of the new chemistry and the new physics.

The scientific agriculture, so-called, of 30 years ago is as dead and buried as the dinosaur. As a matter of fact there was no science of agriculture in those days. All we had were a few opinions and empiricisms. Through some curious quirk of the human brain whenever anything has been set down in a book as a scientific fact it at once achieves an unquestioned acceptance and sanctity. I've made some hearty enemies in the past few years by constantly questioning all the old authorities; by kicking old theories to see if they could stand rough handling. Naturally the high priests of the old order resent being pushed out of the old comfortable grooves.

We have reached a point in the new science of plant genetics, for example, where it is almost possible to produce a plant to specifications. We have produced a hybrid corn that on average good corn land will produce annually more than 100 bushels an acre. It is provided with a very large root system that makes it almost proof against either winds or drought.

There is every reason to believe that we shall soon have a spring wheat that is immune to black rust. The trick in this case was to introduce some of the genes of emmer into wheat. There is a possibility, also, that we may soon produce a perennial wheat, possibly even a drought-proof wheat. All of this advancement in wheat is directly traceable to our new knowledge of plant genetics. Twenty years ago very few people had ever heard of genes and chromosomes. Today they are the common working tools of the plant breeders.

If we want a new berry or a new vegetable, we gather all the plants of the given species and perhaps a few of closely

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Address at the annual dinner of the American Society of Agricultural Engineers, Estes Park, Colo., June 24, 1936. Abridged.

Author: Editor, "Country Gentleman." Charter Member ASAE.

related species. We select one that has the special characteristics we want and cross it with our regular field variety. Then we begin backcrossing with the hybrid and very shortly we have a plant with the characteristics we require. There is not much groping, simply a matter of working to specifications.

Now the true facts in the case are these. Zig-zag clover as it has been known, is a mixture of a large number of closely related plants. Some of them grow close to the ground; some have an erect habit; some will set seed profusely and some are scant seed bearers. All that was needed was to recognize these facts and make proper selections. Within a very few years zig-zag clover that will set seed abundantly will be on the market. And this is why that prophecy is important. It is an acid-soil clover that will grow and thrive to the Canadian border.

PROGRESS IN COMMERCIAL FERTILIZERS

Delving into the history of fertilizers we find that away back in the twenties of the last century Gilbert and Lawes of the Rothamsted Station in England began experimenting with rock phosphate. In a crude analysis of those days they concluded it was made up largely of tricalcium phosphate, but the phosphate was not soluble in water. However, if they added some sulphuric acid the phosphate became soluble. For one hundred years the textbooks gave in considerable detail the reactions which were supposed to take place in the making of acid phosphate and every agricultural college student had to painstakingly write out these formulas.

In the meantime Roentgen had discovered the Xray and later it was discovered by crystalographers that the X-ray diffraction method was the simplest way to make analysis. They applied this to known crystals of tricalcium phosphate and to the commercial product about five years ago and saw the two patterns did not correspond. Then began a series of careful experiments which revealed that instead of tricalcium phosphate, rock phosphate ore contained calcium fluophosphate.

The raw rock carries from five to ten per cent of silica and from three to four per cent of fluorine and it was well known that fluorine has an affinity for silica at temperatures above 1400 degrees centigrade. The chemists who were doing this work began to wonder what would happen if they removed all the fluorine by this process. They got a surprise. When thirty to forty per cent of the fluorine was removed, solubility was less and continued to grow less until the fluorine content was reduced more than 60 per cent. From that point on solubility increased rapidly. When 95 per cent of the fluorine was removed solubility was about 100 per cent.

Commercially the process would be very simple. An ordinary cement furnace operated with a gas flame would supply both the heat and the necessary water vapor. The cost of operation should be lower than the acid process and instead of making half of the phosphorus in the rock available, all of it would be made available, or more than double what is obtained by the acid process.

There is an example of the opportunities in an industry that is more than a hundred years old when modern scientific experiments and methods are employed. You can picture to yourselves what this new knowledge will eventually mean to the fertilizer industry.

Then there is the old fetish about acid soils. The classical agriculturists for more than a hundred years have repeated the dictum that lands must be limed at regular intervals. Formulas were prepared showing how much lime would be required to completely sweeten the soil. But is such a program necessary? The new evidence is not favorable to such a program. Lime is needed? Yes. But not in such quantities. The whole truth of the matter is we are just beginning to learn something about fertilizers, just as we are beginning to learn about insecticides.

Now you may well ask, How does all this relate to agricultural engineering? It is a fair question. And, the answer is obvious. Whatever changes agriculture basically, changes everything connected with agriculture.

Fourteen years ago there was not a single acre of lespedeza, except the little, unimportant Jap clover, on this continent. Today there are 25,000,000 acres. Ten years from now there will be 50,000,000 acres. These are not my figures. They are the figures furnished to me by the men who have studied the spread of the crop.

About ten years ago we, that is, myself and associates, saw the need for a legume that would thrive south of the sweet clover belt. A survey of the field convinced us that lespedezas would perform that service. Our judgment has been vindicated. The old cotton south again has the means, at little expense, to grow one to one and one-half bales of cotton to the acre. Already my friends in the implement industry are selling more haying machinery in the South than they have ever sold before.

With all our boasted science we know almost nothing about poisons. The natives of the Congo Basin and the naked savages of the Orinoco Valley know more than we do. They catch their fish and bring down game by means of simple alkaloidal poisons. Our knowledge until very recently has been limited almost wholly to arsenicals, nicotine and bluestone. One of my self-appointed tasks has been to stimulate research for more effective insecticides that will not be a menace to public health. I am very happy to report that satisfactory progress is being made.

Do I need to illustrate further? Isn't it true that every change that occurs in the lives of our people affects us personally and collectively? And there is no disputing that the new science of agriculture now flourishing so well is destined to produce undreamed-of changes. I ask then, aren't the developments in this field of direct and vital interest to this Society? I believe they are.

THE WORK OF APPLYING SCIENCE

It was because there are so many unsolved problems in agriculture and because we at least have the means wherewith to solve them, that the Jones-Bankhead Law was enacted just a year ago. This law, as you know, provides a perpetual fund for basic research.

Early in my remarks I stated that there were two great factors that might affect the future of this Society. One was the new science, the other politics. The scientific picture is colorful and hopeful. The political outlook is clouded.

I am not here to talk politics, but I should like to call your attention to a situation that this Society and other scientific groups should consider. The civilization of the world today is industrial. It rests upon applied science. Marvels have been accomplished. Those of us on the inside know something of the hours of toil, the endless experimenting, the checking and the rechecking, that have been required to perfect and produce the simplest looking machine, the easiest factory process. Unfortunately the public at large does not know these things. All it sees is the finished work; the result, it thinks, of a few brilliant experiments.

Unfortunately, too, the students in our higher schools of learning who go in for the social sciences, so-called, have no knowledge of how new things are born. And so we have the spectacle of experimenters in government who boast that if one thing does *(Continued on page 250)*

Effect of Soil Moisture Characteristics on Irrigation Requirements

By N. E. Edlefsen

ENGINEERING estimates as to the practicability of proposed irrigation enterprises have too frequently been disappointing because the nature of the soil was not studied carefully. Soil moisture characteristics are phases of such an investigation which have received little attention. Following is a report of a method used in making such a survey, which it is thought will be of interest to irrigation engineers.

This survey was conducted within the Paradise Irrigation District, located in the foothill region on the eastern side of the northern part of the Sacramento Valley in California. It was undertaken in response to a request from officials of the district. They were aware of some peculiar moisture relations of their soil as a result of their experience and a few preliminary tests. They felt that a more detailed study of the condition would help in solving some of the problems with which the farmers of this district have to contend. The climate in this district is milder than on the floor of the Sacramento Valley.

The following description of the soil is quoted from the soil survey of this district[1]: "Aiken clay loam, in undisturbed areas, has a surface 1-inch or 2-inch layer of dark reddish-brown or brownish-red clay loam of heavy texture. It is very granular and rich in organic matter. Below this, to a depth varying from 12 to 20 in, the material consists of brownish-red, dull-red, or red heavy clay loam which is so extremely granular in structure that its heavy texture is masked. It is permeable to water and is easily tilled and contains a moderate quantity of organic matter. A few small spherical iron-cemented pellets are scattered over the surface and through the soil. The next lower layer, continuing to a depth of 3 or 4 ft, contains somewhat more silt and less sand than the material above and is more compact and less granular. However, it appears to be permeable to roots and water. It is of the same color as the overlying material or is slightly brighter red. Both these layers are slightly acid in reaction. The next lower layer, to a depth varying from 6 to 20 or more feet, loses some of its red color and may be dull red, yellowish red, or yellowish brown. It is granular, permeable to water but moderately compact, and neutral or very slightly acid in reaction. It rests on the parent material which, owing to the great depth of the solum or weathered soil material, was seen in few places, but which, where observed, is gray tuffaceous material . . . . . "

"Some carefully planned fertilizer tests carried out under the direction of the farm advisor for two years have shown the following results: For cover crops, potatoes, and garden truck, superphosphate (acid phosphate) has given profitable returns; nitrates have given very slight returns; and potash none; manure gave good returns, but also brought in weeds; sulphur and lime gave slight returns. The effect of any of these fertilizers on the fruit trees was not apparent."

Author: Division of irrigation investigations and practice, University of California.

[1]Watson, E. B., T. W. Glassey, R. Earle Storie, and Stanley W. Cosby. Soil Survey of the Chico Area, California. U. S. Dept. Agr., Bur. Chem. and Soils. Series 1925, No. 4:16,17. 1929.

Purpose and Plan of the Survey. The main purpose of the survey was to determine the water requirements of crops in this district. It was felt that the old method of making these determinations, by measuring the amount of water applied to the soil, was unreliable because usually no measurement is made of the amount of water passing below the root zone. It was decided, therefore, to investigate the amount of soil moisture transpired by the crops as well as the evaporation from the surface of the soil. To make the estimate of the water requirements in this way it was necessary to know: (1) the amount of water available to plants that can be stored in the soil; (2) the rate of use (transpiration and evaporation).

It has been shown [2,3,4,5] that all plants are able to dry the soil in which they have their roots to about the same moisture content before showing any indication of need for water, either by their rate of growth, rate of use of water, or quality of product. This moisture content is spoken of as the *permanent wilting percentage*. It has also been shown that[6,7] the rate of movement of soil moisture a few days after irrigation has slowed down to such an extent that it is negligible compared with the rate of use by plants. This is the maximum amount that can be stored in a soil and is called *field capacity*. The moisture equivalent has been found to be a good measure of the field capacity for most soils. These two moisture contents are characteristic of a given soil and represent, respectively, the lower and upper limits of moisture, available to plants, that can be stored in the field. The moisture content between these two limits is spoken of as *readily available*. If this range is small, irrigations must be more frequent than when it is large. Losses by evaporation during times of application are high so that the quantity of water required to produce a crop on soils having a low available range might be expected to be higher than if the available range were higher.

In this survey, therefore, it was decided to determine the available range of moisture for representative locations in the district.

Twelve locations were selected which were regarded as having soils typical of the area. Approximately 30-lb samples were obtained from each foot section to a depth of 5 ft at each location. Ten tests, in most cases, were made on each foot section of soil to measure the permanent wilting percentage. At least four replications were used in measuring the moisture equivalent. Both measurements were made according to standard procedure.

[2]Veihmeyer, F. J., and A. H. Hendrickson. Soil moisture at permanent wilting of plants. Plant Physiology 3:355-357. 1928.

[3]Hendrickson, A. H., and F. J. Veihmeyer. Irrigation experiments with peaches in California. Calif. Agr. Exp. Sta. Bul. 479:1-56. 1929.

[4]Hendrickson, A. H., and F. J. Veihmeyer. Irrigation experiments with grapes. Amer. Soc. Hort. Sci. Proc. 28:151-157. 1931.

[5]Nichols, P. F., and H. M. Reed. Relation of specific gravity to the quality of dried prunes. Hilgardia 6:561-583. 1932.

[6]Veihmeyer, F. J. Some factors affecting the irrigation requirements of deciduous orchards. Hilgardia 2(6):125-291. 1927.

[7]Veihmeyer, F. J., and A. H. Hendrickson. The moisture equivalent as a measure of the field capacity of soils. Soil Science 32:181-193. 1931.

Moisture Characteristics of the Soil. The notation for the soils studied in this survey is as follows: The letter *P* is used for all soils from the Paradise District, the number following *P* refers to the location within the district, and the number after the dash refers to the foot section (depth). For example, *P*2-5 refers to the soil from the fifth foot depth from location number 2 in the Paradise Irrigation District.

Table 1 shows the average permanent wilting percentage, moisture equivalent, ratio of moisture equivalent (ME) to permanent wilting percentage (PWP), and percentage of readily available water which can be stored in each foot section to a depth of 5 ft, for each of the 12 locations. In the right-hand column is given the inches of available water which can be stored in each foot section, using an average soil density of 71 lb per cubic foot.

The average ratio of the moisture equivalent (28.59) to the permanent wilting percentage is 1.41, instead of 1.84 as found by Briggs and Shantz[8] for the large number of soils upon which they reported. If the ratio of 1.84 is used to calculate the permanent wilting percentage from the average moisture equivalent, 15.54 is obtained, as compared with 22.77 for the measured value. These two values subtracted from the average moisture equivalent give 13.05 and 5.82, respectively, for the estimated maximum percentage of readily available water that can be stored in the Paradise soil. In other words, the calculation of the amount of available water that can be stored in this soil, assuming the 1.84 ratio, is 2.2 times as much as this survey shows it to be. This emphasizes the fact that it is unwise to use this ratio, as has been done in many cases in irrigation engineering, when making estimates of the water relations of a soil.

For comparison, Fig. 1 shows the available range for each of the top 5 ft of soil at one location in the district. It will be noted that all depths have about the same field capacity, but the "readily available" range seems to decrease with depth. Yolo clay loam (surface foot) shown in the lower part of the figure, has about the same field capacity as the Paradise soil but it holds much more available water. The Madera sandy loam has a field capacity of less than half of that possessed by the Paradise soil and yet it is capable of holding more readily available water. It is clear that a knowledge of texture, as indicated by the moisture equivalent, is not a reliable basis for estimating the amount of readily available moisture that a soil is capable of hold-

[8]Briggs, L. J., and H. L. Shantz. The wilting coefficient for different plants and its indirect determination. U. S. Dept. Agr., Bur. Pl. Ind. Bul. 230:1-83. 1912.

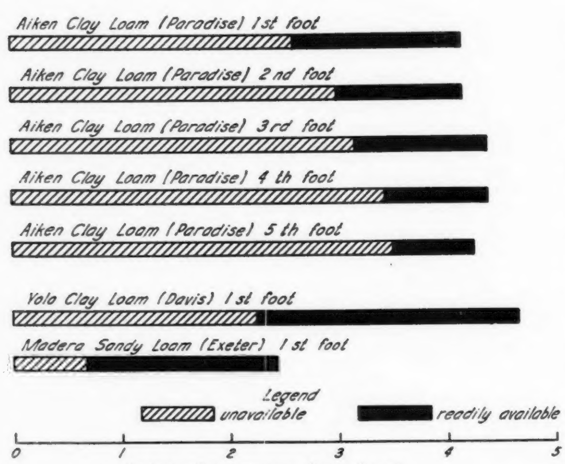

FIG. 1 AVAILABLE AND UNAVAILABLE MOISTURE AT VARIOUS DEPTHS IN CERTAIN SOILS

TABLE 1. SUMMARY OF MEASUREMENTS OF SOIL MOISTURE RELATIONS ON SOILS OF THE PARADISE IRRIGATION DISTRICT

Soil	Permanent wilting percentage	Moisture equivalent	ME/PWP	Per cent available moisture	In available moisture per foot depth
P1-1	20.45	33.33	1.63	12.88	1.70
P1-2	19.66	29.74	1.51	10.88	1.43
P1-3	21.38	30.51	1.43	9.13	1.20
P1-4	23.47	32.21	1.37	8.74	1.15
P1-5	23.09	31.19	1.35	8.10	1.07
P2-1	20.46	31.26	1.53	10.80	1.42
P2-2	23.21	32.00	1.38	8.79	1.16
P2-3	23.41	31.45	1.34	8.04	1.06
P2-4	23.31	31.93	1.37	8.62	1.14
P2-5	24.08	31.83	1.32	7.75	1.02
P3-1	17.23	26.77	1.55	9.54	1.26
P3-2	17.56	25.84	1.47	8.28	1.09
P3-3	19.01	25.55	1.34	6.54	0.86
P3-4	20.75	27.15	1.31	6.40	0.84
P3-5	20.98	28.01	1.34	7.03	0.93
P4-1	19.50	31.45	1.61	11.95	1.57
P4-2	19.87	29.01	1.46	9.14	1.20
P4-3	20.12	28.14	1.40	8.02	1.06
P4-4	21.28	27.66	1.30	6.38	0.84
P4-5	22.05	27.73	1.26	5.68	0.75
P5-1	19.19	30.47	1.58	11.28	1.48
P5-2	21.98	30.46	1.37	8.48	1.12
P5-3	23.18	32.16	1.39	8.98	1.18
P5-4	24.53	32.16	1.31	7.60	1.00
P5-5	25.70	31.12	1.21	5.42	0.71
P6-1	18.43	28.62	1.55	10.19	1.34
P6-2	20.68	28.29	1.37	7.61	1.00
P6-3	21.47	29.18	1.36	8.71	1.15
P6-4	21.14	29.12	1.38	7.98	1.05
P6-5	20.46	28.95	1.42	8.49	1.12
P7-1	17.34	28.47	1.64	11.13	1.47
P7-2	17.10	26.49	1.55	9.39	1.23
P7-3	20.50	29.00	1.41	8.50	1.12
P7-4	21.02	29.63	1.41	8.61	1.13
P7-5	20.90	29.83	1.43	8.93	1.18
P8-1	15.27	24.63	1.61	9.35	1.23
P8-2	16.82	23.79	1.41	6.97	.92
P8-3	20.47	27.19	1.33	6.72	.89
P8-4	21.45	29.00	1.35	7.55	.99
P8-5	22.77	31.16	1.37	8.39	1.11
P9-1	16.33	26.14	1.60	9.81	1.29
P9-2	16.71	24.61	1.42	7.90	1.04
P9-3	17.44	25.39	1.46	7.95	1.05
P9-4	18.40	28.16	1.53	9.76	1.29
P9-5	18.89	29.21	1.54	10.32	1.36
P10-1	15.91	25.92	1.63	10.01	1.32
P10-2	15.99	23.53	1.47	7.54	.99
P10-3	16.85	23.26	1.38	6.41	.84
P10-4	17.88	24.03	1.34	6.15	.81
P10-5	19.39	26.35	1.36	6.96	.92
P11-1	22.01	32.22	1.46	10.21	1.35
P11-2	20.79	30.07	1.45	9.28	1.22
P11-3	21.18	26.38	1.25	5.20	.69
P11-4	21.16	26.42	1.25	5.26	.69
P11-5	20.77	26.96	1.30	6.19	.82
P12-1	20.34	28.79	1.42	8.45	1.11
P12-2	21.49	29.09	1.34	7.60	1.00
P12-3	22.63	29.24	1.29	6.61	.87
P12-4	22.28	28.76	1.29	6.48	.85
P12-5	22.52	28.58	1.27	6.06	.80

ing. In others words, an estimate of the agricultural value of a soil in an irrigated region should take into account these water relations.

For further comparison[2] Table 2 gives values for other typical agricultural soils. It is significant that the inches of available water which can be stored in a given depth of soil is considerably less for the Paradise soils than for the soils of similar texture listed in Table 2. This makes it necessary to irrigate more frequently on Paradise soils than on many other soils to supply the same amount of available water to a crop. Since considerable water is lost by evaporation from the water surface during each irrigation, and from the surface soil immediately following irrigation, the total water required to produce a given crop on this soil is appreciably more than on some other soils, under similar climatic conditions. Where irrigation is accomplished by sprinkling, such as is common in the Paradise Irrigation District, a loss of 25 per cent of the total amount applied might be experienced by evaporation during and immediately following application. The percentage loss by evaporation might be higher for light applications and is probably considerably less than this for applications large enough to wet the top 5 ft of a soil to field capacity, where it has been dried out to the permanent wilting percentage.

TABLE 2. SOME SOIL MOISTURE RELATIONS FOR TYPICAL AGRICULTURAL SOILS

Soil	Number of trials	Moisture equivalent	Permanent wilting percentage	ME/PWP	Available moisture per foot depth, in
FS	226	10.50	3.08	3.41	1.24
TL	78	13.71	4.51	3.04	1.54
J	17	17.07	6.14	2.77	1.83
Y	40	17.16	8.82	1.95	1.40
TC	24	17.30	7.89	2.19	1.58
S	39	21.35	10.20	2.09	1.87
OL	27	23.36	6.12	3.82	2.89
OC	29	24.51	11.55	2.12	2.17
MG	151	25.63	10.47	2.45	2.54
V	24	37.90	19.03	1.99	3.17

Rate of Use of Soil Moisture. The study of the rate of use of soil moisture was confined to mature apple trees and potatoes, which are two of the principal crops of the district.

The method used in sampling soils for moisture under apple trees was to put down six holes distributed approximately evenly along a line through the trunk of the tree and extending on either side, half way to the next tree. The samples were taken in 2-ft depths to a depth of 4 ft. Irrigation in this district rarely wets down more than 4 ft in practice although the roots of fruit trees probably go much deeper than this. The experiment was to measure the amount of irrigation water used by the crops. This estimate was made by measuring the rates at which the soil moisture supplied by irrigation was lost by transpiration and evaporation. Since the irrigation wet down to only 4 ft or less, it was only necessary to sample to this depth.

In Table 3 are shown the average soil-moisture contents at various dates during the irrigation season at two locations. The trees seemed to grow vigorously and produced a normal crop of fruit. No rains fell during the sampling period. The average rate of use from the top 4 ft was figured only for the periods between irrigations where definite information was available. As pointed out earlier, the rate of use of moisture by a given crop, under given climatic conditions, has been shown to be practically constant so long as the major portion of the root zone is in soil, the moisture content of which is above the permanent wilting percentage. It is seldom necessary to irrigate apple trees in this district before June 15 or after September 15, making a total of 92 days during which irrigation must supplement the moisture stored in the soil from the previous winter precipitation.

TABLE 3. AVERAGE SOIL MOISTURE PERCENTAGES IN TOP 4 FT OF MATURE APPLE ORCHARDS—PARADISE, 1936

Date	Location 1	Location 2
June 10	31.1	31.2
16	26.5	27.1
29	24.6	24.2
July 9	26.7	28.3
23	24.8	23.3
Aug. 4	22.7	21.8
11	28.9	25.6
Sept. 1	23.3	22.5
7	28.4	29.9

The data for location (1) shows that an average of 0.244 per cent per day was extracted from the surface 4 ft, or 1.11 ft (13.3 in) of water. Due to high evaporation during the application of water by sprinkling, probably 25 per cent of the water delivered to the soil is lost immediately by evaporation. Assuming this to be the case, it would take 17.7 in of irrigation water per season for apples. This is in addition to the rainfall. Upon the same basis, data from location (2) indicate that 18.8 in would be required. It seems, therefore, that 18 in should be ample for apples in this district even in dry years. In most cases apple orchards would not require this much.

Some data are available on the measured amounts applied. These were collected by H. P. Everett, county agent for Butte County. His data were collected on a younger orchard than is reported on here but he found that about 12 in were applied. He mentions that only about 50 to 60 per cent of the soil was wetted. This would be insufficient to keep mature apple trees growing normally, especially in years of low rainfall.

Potatoes in this district are grown as a spring or as a fall crop. The plots used for this study were 20x30 ft and were planted July 27. The soil moisture percentages for both plots are shown in Table 4. Plot 1 did not receive as much water as plot 2. The vines on plot 1 showed distinct need for water several times, just before irrigation. The irrigation treatment of this plot was regarded as inadequate for general practice.

TABLE 4. AVERAGE SOIL MOISTURE PERCENTAGE FOR THE TOP 4 FT PARADISE POTATO PLOTS, 1936

Date	Plot No. 1	Plot No. 2
July 27	33.2	31.5
Aug. 4	29.5	32.6
11	25.3	26.9
14	28.2	28.9
18	27.1	26.7
21	29.8	28.9
25	27.7	26.9
28	29.1	30.0
Sept. 1	28.5	28.2
3	31.9	30.8
7	30.1	29.0

The potatoes showed indications of wilting in plot 1 when there was still plenty of available water in the second foot; while plot 2 showed no indication of need for water at any time. The root system of potatoes in this soil seems to be confined largely to the top foot of soil. This is another important point to keep in mind in studying the moisture characteristics of a soil, as related to its agricultural value in an irrigated region. The active root zone (depth) is usually characteristic of the crop on a particular soil. There is considerable difference in the root zone of different crops on a same soil. There is also considerable difference in the root zone of a particular crop on different soils.

In hot weather it was necessary to irrigate potatoes twice a week. The surface soil was therefore quite moist at all times, which makes for high evaporation losses. The data for plot 1 show an average daily use (transpiration and evaporation) of 0.426 per cent per day from the top 4 ft. This is regarded as lower than is sufficient in practice. The data for plot 2 show an average daily use (transpiration and evaporation) of 0.596 per cent from the top 4 ft. This represents 0.32 in per day. This figure is high, as pointed out, because of evaporation which takes place from soil that has to be kept almost continuously wet on the surface by frequent irrigation to keep the potatoes growing normally.

The spring crop of potatoes makes considerable growth before irrigation is necessary. Spring rains supply the plant with water during this period. The fall crop of potatoes usually has a short growing period limited by the first frost. The active growing period, during which irrigation water must supply water for transpiration and evaporation, rarely exceeds 55 days for either the spring or fall crops. At the rate per day for plot 2, the total maximum irrigation requirement for a potato crop in this district is 18 in.

SUMMARY

A method of surveying the soil moisture characteristics is applied to a particular area. This survey shows that the soils of the Paradise Irrigation District will hold only a very narrow range of moisture that is available to plants although their field capacity is comparatively high. This makes irrigation more frequent than is necessary on most soils of similar texture. Since some water is wasted at each irrigation, the rate of use of water for a crop of given age might be expected to be higher in this district than in other localities of similar climatic conditions but having a soil which is capable of holding a wider range of available water. In the case of potatoes, this condition is aggravated because the nature of the soil is such that the active roots seem to be confined to the surface foot. The survey shows that 18 in of irrigation water per season is necessary in this district to produce a crop of either apples or potatoes.

The survey shows the need for a knowledge of soil moisture characteristics in making an estimate of the irrigation requirements of crops in a particular location. The influence of the root zone on water requirement of crops is also shown.

Agricultural Engineering and the New Frontiers

(Continued from page 246)

not work, it should be cast aside for something else, until the right answer is found. To the uninitiated it sounds like sense. To you and me it sounds like something else.

Engineers do not build whole new plants and equip them for production just as soon as the first blueprints of a new product are made. If it is a radically new machine, one or two machines are made by hand, if need be. They are tried under a variety of conditions. Then they are redesigned and if the idea seems sound a small factory may be erected. A larger number of machines are made and again they are tested. Then, if a sufficient market appears probable the company goes into production on a limited scale. That is the way industry grows, the way it creates new things. It is the only safe way.

If we could evolve some system whereby everyone who attends a higher institution of learning could be made cruelly aware of how new things are actually produced it might be a great asset for the nation. Sometimes I am half convinced that the world will live in danger of utter collapse, unless we can drive home to every potential leader of men the basic facts that underlie our civilization. This, too, may become one of your tasks of the future.

It is only natural, I suppose, in times of distress, that many foolish things shall be said. One of the expressions that has been stated over and over again is that our frontiers are gone. We can't get up and move on any more—America is finished. These are the implications.

It is true that we have explored our geographic frontiers. We have cut a large part of our timber, dug into our mineral deposits and plowed up our arable land. It is true our physical frontiers have been exploited, but there still remain the frontiers of man's inventiveness.

Who can set the boundaries for the human mind and human spirit? Who knows what new wonders the next year or the next decade will bring forth? Geographic frontiers may be gone, but what of it? We always knew the geographic location of the boundary lines, but there are no boundary lines to human thought and the spirit of man.

The new frontiers are not geographic. They are in the minds and the hearts of the people and they are limitless. We have gone a little way into these frontiers, enough to know that the territory reaches to the stars. Why then cry over our lost frontiers when newer ones and greater ones, and more exciting ones lie just before us?

I grow weary of listening to the people who are always crying disaster, who talk as though the world were finished, who have no understanding and no vision of what lies just before us.

Of course it will take courage, faith and work to open up these new frontiers, but they will be opened, because the necessity exists. The exploration of what lies beyond these new frontiers is the only hope left to civilization. We stand at the edge of the great unknown country today. We have the tools and the equipment to go out on a greater expedition of discovery than Columbus undertook. All it needs is faith, courage, and determination.

I am sure our people have all the necessary qualifications for the undertaking. And, it is men like you, societies like the American Society of Agricultural Engineers, who have the responsibility of leadership in the new expeditions of discovery and development.

To me at the end of thirty years the road ahead is a straight wide boulevard that reaches to the stars. But one of your jobs—perhaps your greatest job—is to see that we don't get pushed off the track.

Chopped Hay Storage in Ventilated Containers

By S. A. Witzel

THE PROBLEM of handling and storing chopped hay has been under investigation at the Wisconsin Agricultural Experiment Station since 1927. Intensive research was started in the summer of 1933 and has been continued through this past season. Since 1933 the project has been in charge of a joint committee consisting of Profs. G. Bohstedt and B. H. Roche, representing animal husbandry; Prof. F. W. Duffee and H. D. Bruhn, agricultural engineering; Prof. L. F. Graber, agronomy; and Prof. E. B. Hart, agricultural chemistry.

Interest increased among farmers in the chopped hay method of storing from 1927 on. Then another factor, the heavy windstorm and fire losses of 1930, 1931, and 1932 entered the picture.

Some farmers rebuilt their barns at greater cost, with masonry walls and reinforced concrete floors for greater protection from fire losses. Some of these barns have burned with a loss nearly as great.

Investigation of 85 windstorm barn losses indicated many cases of weakened framing due to rot and decay. Frequently the framing was not sufficient or properly placed to withstand the wind loads.

A study of the barn problem brought out the fact that fireproof, rotproof and windstorm safe barns could be built one story high at reasonable cost. To remove the hay mow from the barn and to build a barn of insulated masonry construction or at least to build the barn of fire resistant construction would certainly decrease the fire and windstorm losses.

These barn problems all lead to the question, What can we do with our hay? This hay storage problem created further interest because chopped hay lends itself to storage in narrow, ventilated bins similar to corn cribs, and the practical question came up as to whether it might not be possible to store the cut hay after a shorter period of curing than with ordinary hay, thus lessening the risk of weather injury in the field, and also making possible the saving of more leaves by avoiding handling the hay after it was dry. There was also the hope that storing while not quite dry would make possible the production of a hay that preserved a bright green color and other characteristics of a forage hauled freshly from the field. Early in 1933 the committee mentioned above was set up to direct a series of investigations into the different methods of chopped hay storage.

This paper presents a report on the experiments conducted in storing chopped hay with (1) varying percentages of moisture content, (2) different lengths of cut, and (3) in various types of ventilated containers.

The investigations by Duffee and associates were carried out with six wooden bins, varying from 3 to 6 ft wide, 8 ft long on the inside, and 10 ft deep. The side and end walls were double, with 1x2-in slats spaced 10 in apart making up the inside wall, except that in 1936 some bins were lined with wire poultry netting, while the outer wall was of matched boards. The bin walls were built so the tight side could be placed toward the inside if desired. There was an air space of 6 in between the walls, and there were openings to the outside at all four corners. The floor was tight. In addition to the wooden units, an all-metal unit (with the exception of the wood floor and end sections), was used. This provided a double-walled container comparable to some commercial cut hay storage structures. It was made of galvanized steel sheets with louver perforations on the inside wall next to the hay, and tight metal sheets for the outside walls. The 4-in space between the two metal walls was such as to permit a vertical movement of the air, and carry upward the heat produced in the hay in much the same manner as a chimney.

In 1934 a Jamesway metal "Kut-Crop Keeper" was erected on the University farm and used as a part of the equipment for this investigation.

In 1934 a small hay barn, incorporating the narrow ventilated bin principle, such as might be used in typical barns on farms today, was constructed. This barn consisted of two bins with a ventilated wall between. The building is 15 ft long inside, and 12 ft high at the eaves. The outside walls are adjustable to give bin widths of 4 ft, 4 ft 2 in, or 5 ft. The center partition can be removed, giving a maximum bin width of 10 ft 3 in.

Additional containers were used as the study progressed. In 1935 a wood-stave silo 14 ft in diameter was equipped with a floor about 2 ft above the level of the barn floor. The floor was covered with waterproof building paper so as to make it approximately airtight, and a ventilated wooden flue 3 ft square was constructed in the center of the silo. This was constructed so as to have a 3x3-ft connection, at the bottom, to one of the side doors, thus allowing free movement of air up through the chute.

About one ton of cut alfalfa, both first and second crop, of varying moisture content, was stored in each of the different small containers, while larger quantities were stored in the larger containers. The hay was cut into $\frac{3}{8}$, $\frac{1}{2}$, 1, and 2-in lengths. The moisture content was accurately measured in the laboratory. Temperature readings were taken with thermocouples placed at the center of the small storage units at 2.5, 5, and 7.5 ft above the floor level. Still other readings were made at distances of 1.0 ft from one side of the container to the other at different levels above the floor during the early tests. In later tests a temperature cross section was taken at the 5-ft level and single temperature readings were taken in the center at the 2.5-ft and 7.5-ft levels. Temperature readings were taken daily during the period of rapid temperature changes, and weekly from this period until a condition existed where temperature changes of outside air had a greater influence on the temperature of the hay than did conditions within the hay. Contents of the containers were weighed at filling time and at intervals during storage. This was accomplished by mounting the storage containers on wheels which ran on a track built over a large scales.

The temperature of all the samples of hay was found to rise rapidly for the first few days after storage, usually reaching a peak in 10 to 14 days. As the hay loses this heat, there are cycles when, for a short period, the tem-

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Author: Assistant professor and extension agricultural engineer, University of Wisconsin. Mem. ASAE.

perature actually rises, but except for the 2-in cut, the temperature of the outside air seems to have only a limited effect upon these fluctuations in the temperature of the stored hay until the curing process is over. In nearly every instance the temperature of the hay was uniformly higher near the top of the stored hay. For instance in one bin, twelve days after storing the hay, when the temperature 2.5 ft above the floor was 158 F, (degrees Fahrenheit) at the 7.5-ft level, it was 189 F. It is not known whether this is due to heat rising within the hay, or to greater heat being generated in the upper layer.

The height to which the temperatures rose was found to be increased with (1) increased moisture in the hay at the time of storing, (2) increased width of the hay container, i.e., distance from one ventilated wall to the other, and (3) shorter lengths of cut, resulting in greater density, or more pounds of hay per cubic foot of storage space.

Alfalfa hay cut 1.0 in long, having a moisture content of 19.4 per cent at the time of storing in bins 5 ft wide, developed a maximum temperature of 113 F. For other moisture contents the maximum recorded temperatures were 22.1 per cent moisture, 118 F; 22.4 per cent moisture, 120 F; 25.8 per cent moisture, 118 F; 27.6 per cent moisture, 124 F and 38.8 per cent moisture, 152 F.

The maximum recorded temperature was 189 F, which was reached in a bin 6 ft wide filled with alfalfa cut 3/8 in long, and containing 40 per cent moisture when stored. This hay became a moldy mass unfit for feed, but it is significant that the maximum temperature attained fell far short of the 500 F which is commonly considered as necessary for spontaneous ignition to occur in hay. This 189 F temperature at the 7.5-ft level was reached 13 days after storing, and, as in the case of the other bins that heated, the hay remained close to the maximum temperature for about ten days, then dropped steadily for approximately 100 days, the temperature being 75 F on November 20. It is thus probable that storing cut hay in relatively narrow, ventilated bins may prevent spontaneous combustion, although further trials will be necessary before final conclusions are drawn.

CONDITION OF HAY REMOVED FROM THE BINS

The trials were completed by finally removing the hay from the containers and carefully recording its condition. Hay cut to 1.0 in or less and containing not more than 20 per cent moisture at the time of filling the bins came through the storage period with a bright green color. Hay containing appreciably more than 20, but less than 32 per cent moisture at the time of filling, turned brown, except for a narrow band next to the outside of the bin. This hay proved palatable for cattle, and was deemed suitable for feed, but due to its loss of carotene (pro-vitamin A) was not as nutritious as the drier hay which had retained its green color. The loss in weight of the dry matter in this brown colored hay was surprisingly little, being less than 5 per cent on the average, and in this respect quite comparable with hay put into storage with 20 per cent moisture or less.

All experimental lots of hay containing more than 32 per cent moisture at time of storage were so injured by fermentation they were not suitable for feed. Much of the material had a strong, moldy odor, while some of it actually rotted. In certain spots the hay was bleached white similar to fire-fanged horse manure.

In 1936 the length of cut of the alfalfa was increased in some of the trials to 2.0 in. The dry season made it difficult to put up hay with enough moisture to determine definitely the upper safe limits for the storage of alfalfa cut 2.0 in long. By increasing the length of cut from 1.0 to 2.0 in (1) much lower temperatures resulted; (2) keeping qualities were improved considerably, as indicated by green color and almost complete absence of must or mold in hays having up to about 25 per cent moisture; (3) bins with netting walls seem to offer no advantage over those with slatted walls, with the results measured in terms of quality of hay and also in terms of the temperatures observed in the hay; (4) reduced density from an average of 7.69 lb per cu ft for the 1.0-in cut to 5.41 lb per cu ft for the 2.0-in cut, in bins 10 ft deep; (5) the atmospheric temperature tends to influence the temperature of the hay from the beginning of storage, especially on the sides of the container, for example, maximum temperatures occurred 1.0 ft from the south side rather than in the center as is the case with shorter cuts of hay. The maximum recorded temperature was 108 F.

CONCLUSIONS

General conclusions which can be drawn at this time indicate that the major factor determining the temperature and keeping qualities of the hay is the density or length of cut. Whether this coarse length of cut affects it only through density is a question. It may be that additional cuts exposing additional fractured cell structure may be a factor, or it may be that long straws with long air tubes along the sides of the straws as contrasted to short straws or short air tubes may be a factor. In any event, the longer cut undoubtedly keeps better and does not heat as much as shorter cuts.

Width of the storage unit is not a very important factor. The differences in the keeping qualities and temperatures between a 3-ft box and a 9-ft box are not extremely marked, although definitely measurable. However, it will probably be a controlling factor, along with density, in the elimination of danger of spontaneous combustion in the storing of hay that is too damp.

The nature of the ventilation wall is apparently not an extremely important factor. Up to the present time, tight walls have been tried, slatted walls with about 30 per cent of the surface open, and walls lined with netting, where fully 90 per cent of the surface is exposed to the ventilating flues. In the few trials observed, there is no appreciable difference between the slatted walls and the netting walls. In 1935, a tight box was experimented with, also a tight silo, 14-ft in diameter, with a 3x3-ft ventilating chute in the center. The tight box and the tight silo resulted in somewhat higher temperatures, but not at all serious, and the keeping qualities of the hay within the tight wall apparently were not much poorer than those in the ventilated container, thus indicating that while ventilation has some value, it is not a factor of extreme importance.

One factor has been demonstrated with regard to a ventilated wall. If the hay is of rather high moisture content, let us say 30 per cent, and a tight wall is used; when the hay heats, causing moisture to be liberated at a rather high temperature, the moisture moves to the outside of the hay mass, comes in contact with the tight wall, which of course is cooler, and condenses there. The moisture content of the hay next to the wall is thereby increased and mold or even rotting will occur. The wall design therefore should be such as to permit the dissipation of this moisture, and also it seems likely that a type of wall should be used that will keep down condensation as much as possible.

Results of Experiments on Hydraulics of Drop Inlets and Other Erosion Control Structures

By L. H. Kessler

DURING the training period of the young engineers who were to become part of the personnel of the ECW in Wisconsin, in June 1933, certain problems arose relative to the hydraulic design of structures for erosion control service. E. R. Jones, director of ECW erosion control, requested me and my assistants to investigate these problems relative to the hydraulic performance of proposed structures. An extensive series of experiments were conducted in the hydraulic laboratory and the results and conclusions were given to those in the field in blueprint form. Later, due to ECW, CWA and Wisconsin Engineering Experiment Station appropriations, it was possible to continue this research in more detail.

Obviously, models had to be used in the experimental work in place of the prototype, but by interpreting the data according to the laws of hydraulic similitude, it is believed the hydraulic characteristics and behavior of the several types of structures investigated are definitely known for practical work.

The ultimate object of the work was to develop:

1 The type of spillway design that would give the greatest discharge

2 The outlet design that would safely dissipate the energy in the water before it was discharged from the structure

3 Standard designs of the above items that would demand the least amount of steel and concrete

4 Standard designs that could be built by unskilled labor

5 The preparation of hydraulic tables and charts for the selection of size and type of spillway structure.

Reinforced concrete and masonry structures seemed to be the best fitted for permanent control of erosion in gullies.

All designs investigated relate to the spillway section of

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Author: Acting chairman, department of hydraulic and sanitary engineering, University of Wisconsin.

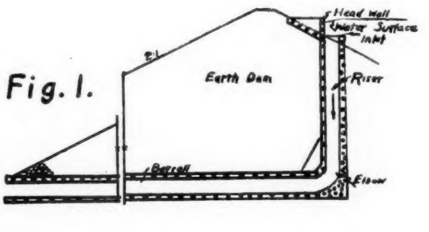


Fig. 1.

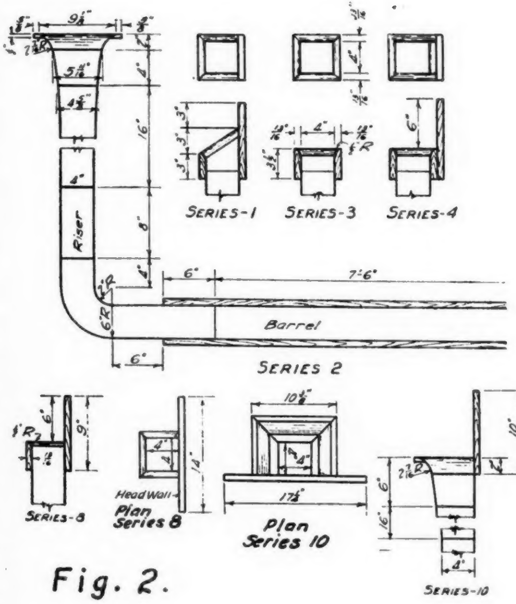


Fig. 2.

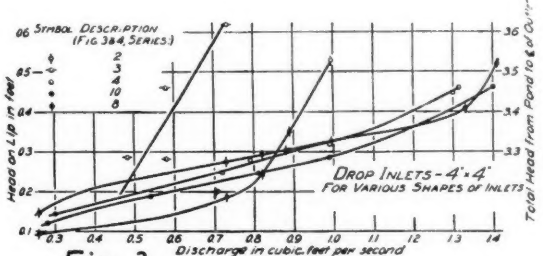


Fig. 3.

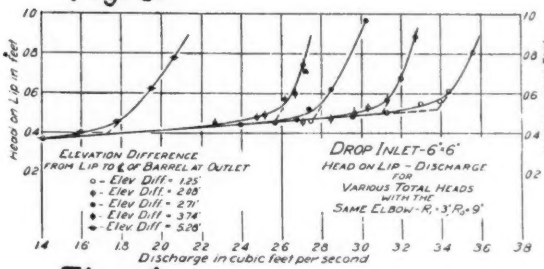


Fig. 4.

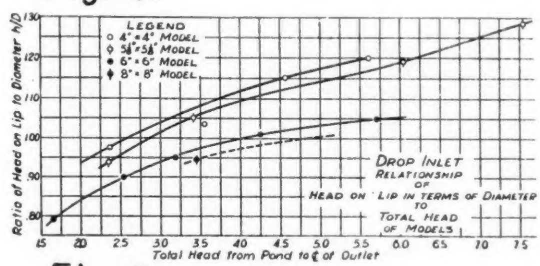


Fig. 5.

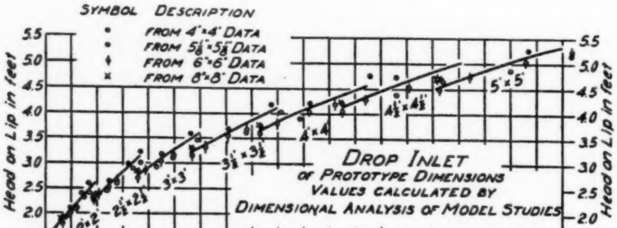


Fig. 6.

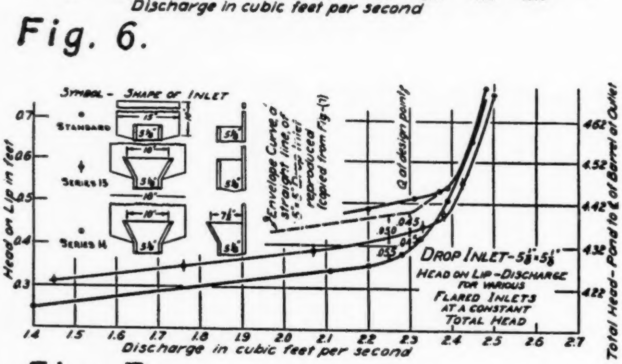


Fig. 7.

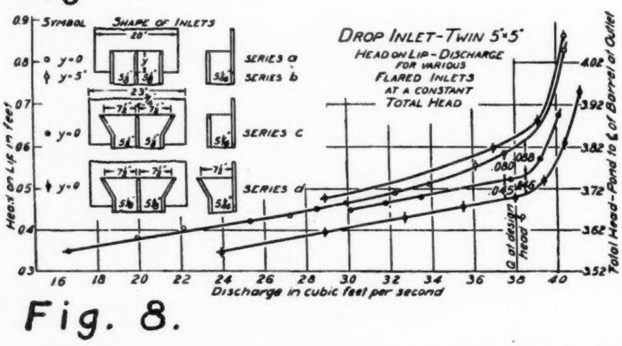


Fig. 8.

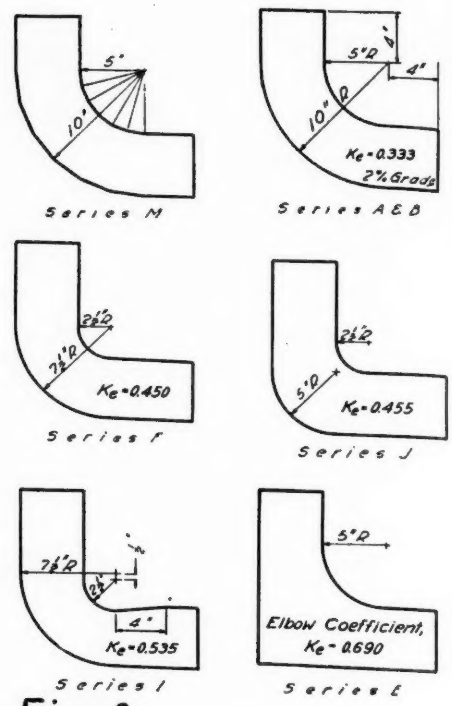


Fig. 9.

an earth dam or dike that will permit water to be discharged safely through the dam, over a weir section, or through a flume or channel into the gully below. If the dam and spillway are successful, gully erosion ceases, as the gully upstream from the dam silts up, preventing the "eating back" of the gully, caused by the respective hydrological and physiographical conditions of the locality.

The object of this paper is to give briefly a description of the types of structures and the most important results and conclusions, including some of the tables and charts that may be valuable to engineers engaged in design.

The Drop Inlet. Fig. 1 shows a structure used to discharge the runoff from the pond above the earth dam into an inlet, then down a riser through an elbow and barrel imbedded in the earth dam and thence into the gully below the earth dike. Total practical heads should be below 35 ft.

Series 2 to 10 (Fig. 2), inclusive, indicate a few of the types of inlets studied, with Fig. 3 showing head-discharge relationship on one size of model. The "morning glory" (Series 2) was ideal for low heads and permitted greater discharge. However, a vortex formed at higher heads. Discharge increased slightly with the head and the barrel of the structure never flowed full. The square inlet (Series 3) behaved in general like Series 2, indicating a vortex that reduced capacity. Both inlets could be compelled to flow full, but not at reasonable heads. Higher earth fills would be required above the inlet. Various types of baffles, piers, and headwalls were tried to eliminate the formation of a sustained vortex. The head wall (Series 4, 8 and 10) solved the vortex problem with a large increase in capacity of the inlet. Fig. 3 indicates the respective increase in discharge. The high velocities around the ends of the narrow head wall were alarming, so the wall was extended as in Series 8 and 10 and very little change was noted in head-discharge characteristics. The final standard design recommended was very similar to Series 8 with a well-rounded lip. Due to velocity distribution, riprap is needed around the ends of the headwall and between headwall and riser. Later investigations (Fig. 7 and 8) showed that a "flared inlet" caused less surging of the water above the inlet. Vacuums in the riser and pressures in the barrel showed less fluctuation. Furthermore, the head on inlet in Fig. 7, Series 13, decreased 10 per cent below that of the standard inlet. This flare increased the length of the crest one-third and doubled the area at the crest. In Series 14, with the crest length increased two-thirds and the area at crest tripled, the head decreased 20 per cent over that required by the standard drop inlet. The most efficient flare is one with a maximum diameter twice that of the riser, and depth equal to the pipe diameter.

The ratio of the head on the inlet to the diameter of the inlet is important, particularly at what is called the "design point." Fig. 4 shows characteristic head on lip-discharge curves for several total heads causing flow through the entire structure.

Note the abrupt change in discharge curve characteristics. Any additional freeboard above the required head on lip, to make the standard drop inlet flow full, cannot be relied upon to provide any factor of safety in discharg-

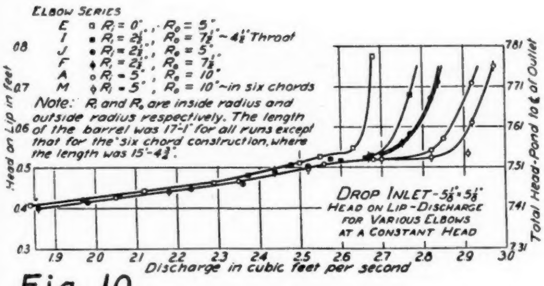


Fig. 10.

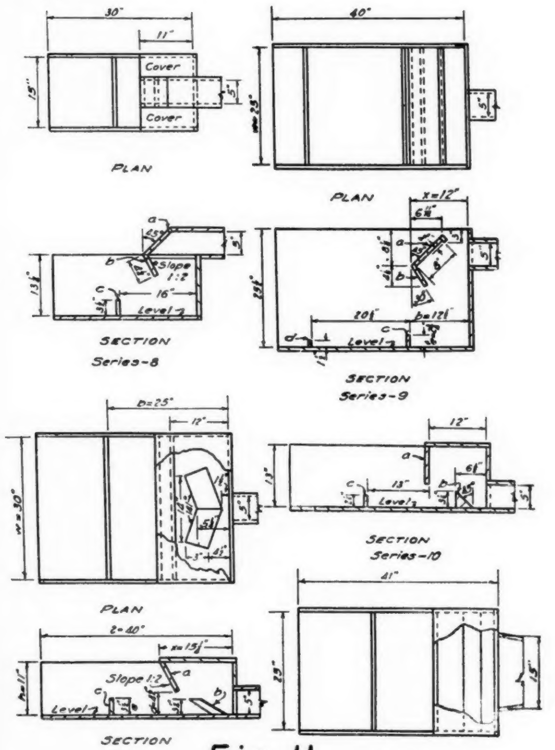


Fig. 11.

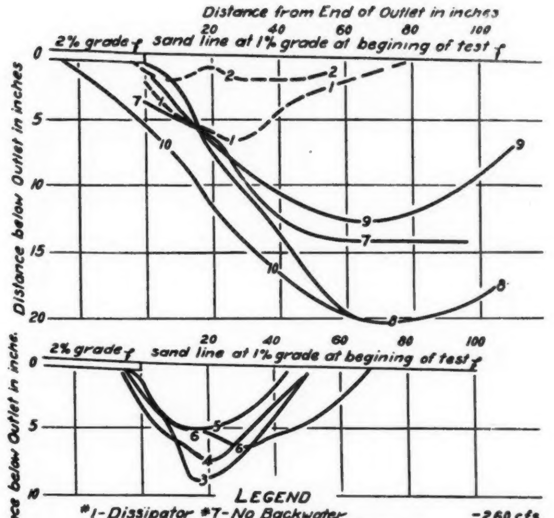


Fig. 12.

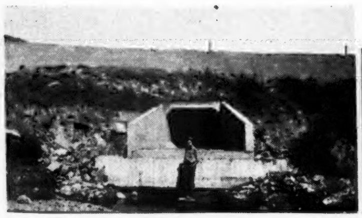
FIG. 12 (ABOVE) PROFILES OF SAND ALONG CENTER LINE BELOW OUTLET SHOWING UNDERMINING OF STRUCTURE

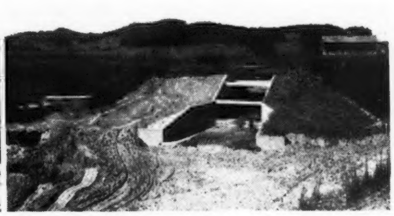
TABLE 1

Field conditions see Fig. 10 for quantities below Size D Ft.	Disch. Q Ft.	Total head H Ft.	Head on lip (H) from Fig. 8 Ft.	Ratio (h/D)	Ratio (h/D) from Fig. 5
2½ x 2½	161	20	2.46	0.984	1.018
2½ x 2½	189	30	2.74	1.095	1.104
4 x 4	495	30	4.08	1.02	1.004
5 x 5	791	30	4.80	0.960	0.952

ing capacity of the drop inlet. This is one of the weakest points or disadvantages of this structure. If the structure is improperly selected, the pond can rise rather quickly and overtop the dam. Fig. 5 and Table 1 indicate that ratios of (h/D) from 0.952 to 1.30 are likely to hold for this structure. A ratio of not less than 1.2 is recommended for design purposes.

The discharge of the prototype is by hydraulic similitude equal to the discharge of the model multiplied by the five-halves power of the scale ratio (N) of the prototype to the model. Charts and tables of capacities of large drop inlets (not shown here) were constructed. From these data Fig. 6 is shown, where a comparison is made as to discharge capacity of the structures, as estimated from various sizes of models of varying scale ratio.





OUTLET STRUCTURES

Fig. 14 (Left) Outlet of a 6x6-ft drop inlet with original grade about 1.5 feet below outlet. This structure has carried three medium flood discharges. Fig. 14 (Center) Head spillway measuring 40x14x7.5 ft, with a gradient of one per cent in sand having little cohesive properties. Fig. 15 (Right) Head spillway repaired after flood with apron 3 to 4 ft below original outlet

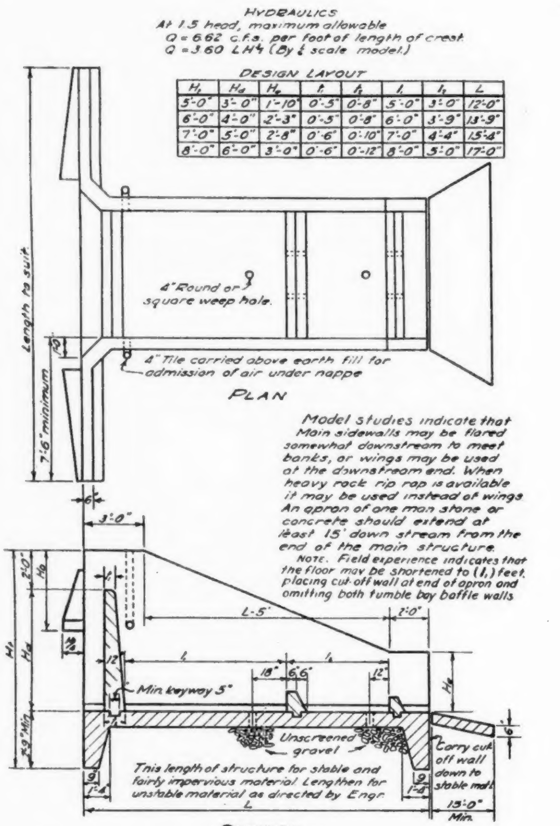


Fig. 16.

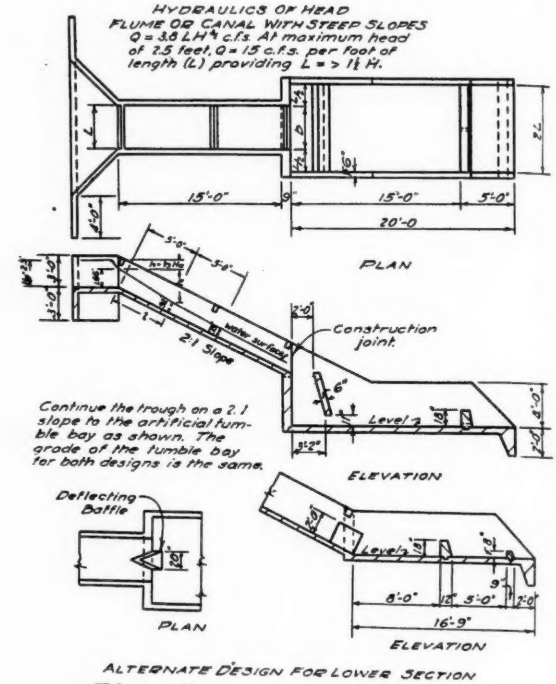


Fig. 17.

This chart infers that the manner in which the water is carried away from the inlet should have no effect on this analysis. The assumption is that the performance of the inlet is not determined by downstream conditions. The use of these curves for design purposes is demonstrated in Table 1 as one method in arriving at the proper ratio of head on lip to diameter of inlet.

Elbow or Bend Loss in Head. Certain forming or construction difficulties often call for various types of elbow design. Twelve types constructed of sheet metal, were tested and some of them are shown in Fig. 9, in order of the best hydraulic characteristics, namely, Series M, A and B, F, J, I, E. A well-ponded inlet was used and various ratios of lengths of barrel to diameter of barrel were tested. The loss caused by the elbow is not so much in the elbow itself, but occurs as additional friction forces due to increased disturbances set up some distance downstream from the elbow. The loss caused by the elbow is not dissipated entirely in the length of the barrel unless the length equals 30 diameters. Where larger barrels are used in the field, we can expect a little less elbow loss and slightly greater discharges for the comparable total head. It will be observed that elbow loss will vary from about 30 to 70 per cent of the issuing velocity head where the coefficient K_e is used in $K_eV^2/2g$.

As the coefficient of bend loss increases, the magnitude of the surges or pressure changes increase throughout the entire model. Series E, the square elbow, is by far the worst offender. Unless the proposed spillway will not flow full in the field, such as a 2x2-ft structure on a small drainage area, this elbow (Series E) should not be constructed.

Twin Inlet Structures. Twin inlet structures (Fig. 8) can be used in place of large drop inlets. These structures should be flared on three sides at ½ to 1 extended down one diameter. The head on the lip will be reduced about 32 per cent compared to a twin structure with no flare. Twin structures with a common wall, and flared on three sides, have a capacity only about 6 per cent less than two separate structures without a flare.

Slope of Barrel. Tests indicate that when the barrel is placed on a slope greater than the hydraulic grade line required to produce flow through the barrel itself, the elevation of the water surface in the barrel will not be in contact with the crown. The barrel cannot flow full. Air will travel from the outlet back to the elbow. The air can travel around the elbow, break the vacuum in the riser, and change the hydraulic behavior of the inlet. The models indicated under this condition that the dam would be over-topped quickly.

Maximum slope of barrel for prototype recommended by the author is:

$$h_f/L = (0.010/D)\ V^2/2g \quad (h_f,\ L,\ D \text{ in feet; } V = \text{ft/sec; } g = 32.2 \text{ ft sec sec})$$

The Outlet Section. Flaring the outlet section 1 ft in 10 and keeping it submerged will increase the discharge of the structure slightly, lower the velocity at efflux, and cause partial vacuum in the barrel. The loss of head in the flare is about half that of the best elbow. However, there are probably so few places where submergence of outlet can be maintained that the flared outlet at this time will be of little significance.

Outlet Structures or Energy Dissipators. These are structures that can be located on the downstream end of

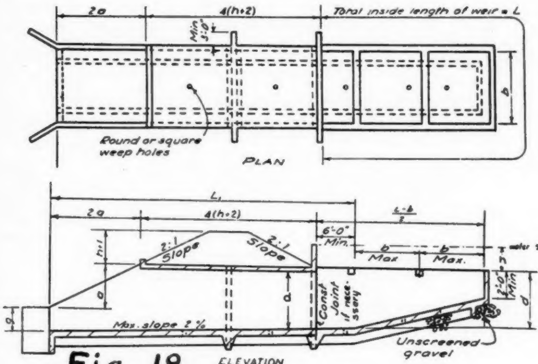


Fig. 18.

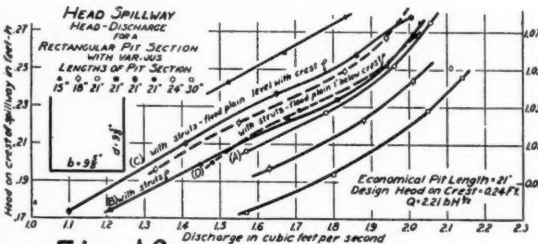


Fig. 19.

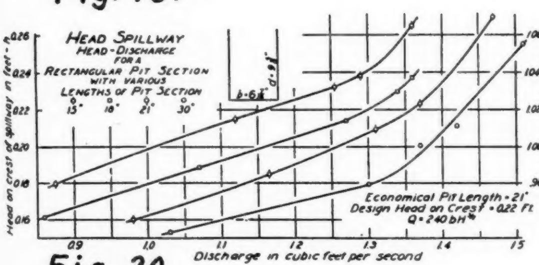


Fig. 20.

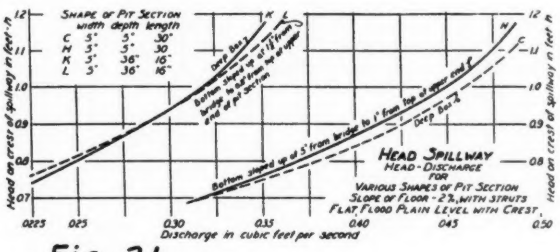


Fig. 21.

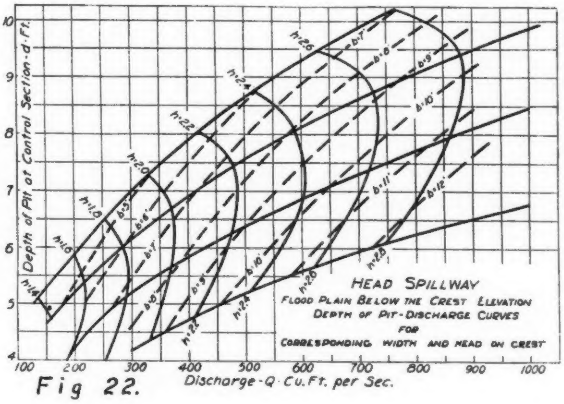


Fig 22.

the barrel of a drop inlet in order to dissipate energy and eliminate erosion of the dike where it intersects the bottom of the gully. Fig. 11 indicates four of a series of ten dissipators that were tried. Some of the designs are adequate for large quantities of flow and others for small quantities. Fig. 12 shows erosion in sand below outlet with and without the dissipators, and it shows also the favorable effect of backwater on the erosion problem. A great deal of time is spent in designing the structure and inlet conditions, but it is also important to consider how we are going to release the water that has been taken into the structure. While the studies are by no means complete, indications are that in alluvial deposits, it may be possible to observe initial cutting even after a dissipator is used. However, it appears possible that the hole created after a few floods may not enlarge seriously so as to endanger the structure, since a suitable tumble bay is created to assist in final dissipation. It is evident from Fig. 12 that the square outlet is likely to cause serious erosion of the gully and undermining of the structure.

It is possible to build dissipators as in Series 9, Fig. 11, where the tumble bay box is well below the outlet of the barrel.

The Notch Spillway. Fig. 16 shows a structure similar to the ordinary type of fixed spillway dam with abutments, side walls, apron and tumble bay for discharging water at a head of not more than 2 ft over the dam and a total drop not exceeding 12 ft.

For the design shown in Fig. 16 the discharging capacity can be computed as $Q = 3.60\ L\ H^{3}/^{2}$. I believe that the extra cost of the tumble bay and apron is warranted; otherwise an hydraulic jump is likely to form off the apron with subsequent erosion endangering the structure.

The Head Flume. Fig. 17 shows a structure located at the head of a gully such as a canal or chute with a steep slope permitting small discharges to flow from above the earth dike down to the gully below, after passing into a special energy dissipator section or tumble bay to avoid erosion below the structure at gully invert.

The control section is at the inlet which acts as a broadcrested weir with discharge formula shown in Fig. 17. The hydraulics of this structure is interesting because it has both non-uniform and uniform flow behavior. It is believed vertical sidewalls on the flume are better than walls that would make a trapezoidal cross section of the flume. The alternate design shown is easier to construct and perhaps cheaper, but not as reliable under all flow conditions. The force on the baffle wall of dissipator in pounds in the normal design is $P = AV^2$. The flume can be designed so that the cross section above the dissipator can be narrowed. Such a design calls for elevating the deflecting baffle so that the entire impinging stream of water will be deflected downward.

The Head Spillway. Fig. 18 shows a structure usually located near the head of a gully, but capable of discharging large quantities of water under about 2 ft of head into a box or pit section with the downstream end open. The maximum height of fall is about 12 ft and the structure can be long in length and so made as to provide a roadway across the channel section. It should be useful where low earth dikes only are required, and particularly in

replacing culverts in highway work that are known to be causing erosion at or near the highway.

The flow of water over the three sides of the box has little effect in causing movement of water in the pit and channel section. Water heads up in the pit section and this potential head is transformed into velocity head. At the bridge, channel, or control section the entire quantity of water is flowing at relatively low velocity and great depth. Within a short distance (a length of about the height of the pit section) the water is flowing at apparently its stable depth, which in most cases is above the "critical depth" or section of minimum energy. Great refinement in slope determination for critical depth of flow is believed unwarranted.

The loss of head is surprisingly low, between 10 and 20 per cent of the total head (H) measured from the surface of water in the pond to the floor of the channel at the critical section.

More water discharges over the weir crest near the bridge than over the upstream end of the pit section. This is particularly true as the submerging of the weir becomes appreciable due to "backwater". At "design condition" the water is falling just beneath the bridge, and it heads up in the upper end of the pit section so as to produce a 75 to 100 per cent submergence of the nappe of the broad crested weir.

There is a definite length of pit section or "economical length" where the total concrete required is a minimum in respect to the amount of water discharged. Figs. 19 and 20 show economical pit lengths for two different models.

An alternate design making the pit depth shallow at the upper end (Fig. 21) indicates that the structure will discharge almost as much water as a very deep pit (length of pit and weir crest remaining the same).

Fig. 19 also indicates that struts across the pit section, to provide construction of a reinforced beam band in the top of the pit walls, decrease the discharge about 2 per cent. If silt or sand of the flood plain is level with the top of crest of the pit, the discharge will be reduced by about 8 to 10 per cent (Compare curve C with curve A).

Table 2 shows data for selection of head spillway dimensions and also the effect of flood plain level with weir crest in decreasing the discharge over that which would occur before the pit section is silted up. Fig. 22 is a chart in which an attempt has been made to simplify the selection of the size of structure.

Any design is largely made by trial and error. Preliminary estimates can be made by equating $Q = 2.61\ L\ h^3/^2$, where $L =$ total length of crest of pit section and h equals head on crest. The width b can be estimated from the broad crested weir formula, found to be about $Q = 2.3\ bH^3/^2$, where $H = h$ (above) $+ D$ (depth of channel). (See Fig. 18). It is regretted that it is impossible to develop or present a precise formula based on flow and minimum energy at the control section. Flow at critical depth is not assured.

Further Research. Two research projects are in progress on the head spillway whereby the effect of slope of the gradient above the pit section is being studied, and the flaring of the channel section. Also it is believed it may be possible to narrow the pit section near the upper end without materially affecting discharge characteristics.

Field tests on completed structures are needed to check the hydraulic performance of the structure and hydraulical conditions of the respective drainage areas. Any data so obtained with reasonable care will be most useful in advancing our knowledge of hydraulic characteristics and behavior of permanent structures and drainage areas.

TABLE 2 DATA FOR SELECTION OF HEAD SPILLWAY DIMENSIONS

Depth of pit at control section d-ft	Width of pit b-ft	Head on crest h-ft	Head through structure $H = d+h$-ft	Length of pit L-ft	Discharge: Earth below level of crest Q-sec. ft.	Discharge: Earth at level of crest Q-sec. ft.	Ratio of width to depth
1	2	3	4	5	6	7	8
5′	10′	2.3	7.3	19	457	419	2:1
5′-6″	11′	2.6	8.1	21	573	526	
6′	12′	2.8	8.8	23	723	664	
6′-6″	13′	3.0	9.5	25	884	812	
7′	14′	3.3	10.3	27	1060	954	
8′	16′	3.7	11.7	30	1480	1330	
5′	7′-3″	1.8	6.8	14	271	244	3:2
5′-6″	7′-9″	2.0	7.5	15	343	308	
6′	8′-6″	2.2	8.2	17	429	386	
6′-6″	9′-3″	2.3	8.8	18	524	472	
7′	10′	2.5	9.5	19	632	568	
8′	11′-6″	2.9	10.9	22	876	789	
9′	12′-9″	3.2	12.2	24	1176	1058	
5′	5′	1.5	6.5	11	178	160	1:1
5′-6″	5′-6″	1.7	7.2	12	227	205	
6′	6′	1.8	7.8	14	282	254	
6′-6″	6′-6″	2.0	8.5	15	346	312	
7′	7′	2.1	9.1	16	414	373	
7′-6″	7′-6″	2.3	9.8	17	490	441	
8′	8′	2.4	10.4	18	578	520	
9′	9′	2.7	11.7	22	782	703	
5′	3′-4″	1.4	6.4	11	130	117	2:3
6′	4′	1.7	7.7	14	204	183	
7′-6″	5′	2.1	9.6	17	356	320	
9′	6′	2.5	11.5	20	555	500	
10′-6″	7′	2.9	13.4	23	828	746	

Stock Feed Milled at Farmer's Own Barn

DURING the drought, it was discovered that a remarkably fine stock food could be obtained by mixing almost any food the farmer had, beet pulp, oats, corn, etc., with black strap molasses. This converts feed that is short in carbohydrates and long on bulk into a tasty, rich, appetizing product of much higher value.

However, this has necessitated a long trip to the mill, and another complicated operation to impregnate the ground feed with molasses. But today farmers near Lapeer, Michigan, don't have to worry about these costly operations, for their mill now comes to their own barnyard, regularly every two weeks!

This outfit consists of a portable mill and a molasses impregnator mounted on a truck. The truck motor, through a specially built split shaft power take-off, furnishes the power.

The farmer has his feed ready when the truck is due, the feed is ground and impregnated with molasses in a few hours, and the truck departs to the next farm on its schedule. The farmer is left with ample high grade prepared feed, ready for instant use, without the expense and time of hauling, a remarkable instance of the mountain not only coming to Mohammed, but making a tidy profit in doing so.

Rural Electrification Trends in Europe

By R. B. Gray

AS MOST of us know, a far greater percentage of farms in the various countries of Europe are using electricity than is the case in the United States. Authoritative sources in this country estimate that 50 to 100 per cent of the farms in the various countries abroad have electricity, as compared to our own 12 per cent. For the seven countries which I visited, namely, France, Italy, Germany, Denmark, Sweden, Belgium, and England, these figures appear to be reasonable, from my limited observations. The density of population and the custom of farm people living in villages are probably favorable to this high percentage of use abroad.

France, my first stop, has made rapid strides in rural electrification since the war, and is now credited with having electric service available to over 90 per cent of the rural communities. On one farm just outside of Paris, electric lights were used extensively and a portable 10-hp motor was available for threshing and other belt work. A 3-hp stationary motor operated a deep well pump in an open well in the barn, pumping water to a tank set in a hillside. This was a more or less typical set-up for that region. On an adjacent farm, a large electrically-driven blower was being installed for blowing air through grain to dry it. The grain was to be placed 3 ft deep on the concrete floor of the haymow. Cold air in dry weather and warm air in wet weather was to be blown through the 6-in concrete headers located on the floor at opposite sides of the mow. To distribute the air through the grain, small ducts 12 in apart led out from the headers. The ducts consisted of 2.5x2.5-in angle irons laid open side down on 3/16-in steel strips laid on the floor.

The agricultural school at Gignon, not far from Paris, made use of a two-unit electric plowing outfit which pulled the plow back and forth across the field by means of a steel cable. Each unit consists essentially of a heavy steel frame supported on four flanged wheels and fitted with two electric motors—one of about 40 hp, for plowing, the other of about 10 hp, for moving the unit across the headland; two drums; and the operator's seat. One drum was mounted so that the electric cable could be unwound back of the outfit as it moved down the headland, and the other to carry the steel cable attached to the plow. This was a cumbersome machine and probably a white elephant, but it was used in preference to spending money for a tractor, funds being scarce.

Electric milkers are now in satisfactory use, although previously there had been trouble because of severe vacuum injury to the cows' udders.

Italy, the next country visited, has a slightly larger percentage of farm communities electrified than France. Probably over 50 per cent of the electricity used for agricultural purposes is for irrigation. At the agricultural mechanical school just outside of Rome, agricultural applications of electricity, including the use of fractional horsepower motors, were being taught, along with the use of other kinds of power, such as tractors. While water power appears to be abundant, power rates in Italy were high, about 15 cents per kwh (kilowatt-hour). This was due in part, I was told, to the desire to get the power plants, transmission lines, etc., paid for in a period of a few years. Then the rates would likely be reduced.

On a farm in northern Italy, electric power was used for operating a thresher, a rice mill, and other belt-driven machinery, including irrigation pumps. Use was also made of an electrically-driven ventilator in a dairy barn. A number of electric plowing outfits had been in use in this region, but were rapidly being superseded by tractors. It might be of interest to note that the main railroad lines from the French border south to Rome and Naples have been electrified within the past few years.

The next stop was Germany, where 90 per cent of the farms are credited with having electric service. At the technical high school at Munich, Dr. Geo. Kuhne showed the methods of instruction used to establish electricity. He had a room of a house in section for the students to wire; also portable motors with switchboards mounted thereon to facilitate connecting up to a power source and measuring the power required by belt-driven machines. Quite unique were some of the arrangements in his lecture room. By pushing a button he could put the ventilator in operation, move the blinds over the windows to darken the room for showing a movie, and, I believe, if so disposed could lock the doors against tardy students. Investigations for reducing draft of plows by the use of electricity were under way. By insulating the plow body from the frame, and the knife colter from the frame and plow body, and passing a direct current from the colter through the soil to the plow body, Dr. Kuhne had obtained a reduction of draft approaching 20 per cent. The source of current was a small-capacity generator mounted on the rear of and driven by the tractor pulling the plow. One ampere seemed to be the optimum value for the current when operating in the one soil, a medium clay having a moisture content of between 25 and 30 per cent, with the plow traveling at a maximum of 2.25 mph (miles per hour). While this subject is not new, it is interesting to note that Dr. Kuhne's method holds out considerable promise. It might be of interest to note that the soil in this plot where these tests are made is prepared by an electric motor-driven rototiller.

At a rural electric demonstration farm near Stendal, not far from Berlin, the current from the transformer pole was conducted under ground through steel conduits, one branch leading up the outer side of the house wall and the other branch coming up the outside of each service building such as horse stable, cow barn, etc. The wiring in the house was carried in nonmetallic sheathing, not concealed, though painted the same color as the walls. As most buildings, both dwellings and out buildings, are of brick or stone, concealed wiring would probably be very difficult to install. The light and power circuits, including stove, were on one meter, the steam generator for cooking potatoes for hog feed on another, and the kitchen water heater on another. The base rate for power was determined from the acreage on the farm, at 40 pfennigs (16 cents) per hectare ($2\frac{1}{2}$ acres). The current used cost 8 pfennigs (3.2 cents) per kilowatt-hour, except on the water heater,

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Author: Chief, division of mechanical equipment, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. ASAE.

for which there was an off-peak rate of 4 pfennigs (1.6 cents) from 10 p m to 4 a m. This farm was sponsored mainly by one of the electric companies, which had three other demonstration farms of similar type in this region. Practically every small farm in Germany has a small thresher with electric motor drive, and the number of motors used in agriculture has increased by about 60 per cent since 1925.

Considerable interest in electricity for heating is manifested throughout Germany, and several thousand electric ranges are in use in that country.

In Denmark, electricity is used mainly for such purposes as driving small threshers and hay choppers, as well as lighting. Current appeared to be rather expensive. The main supply is secured through underwater cables from either Norway or Sweden. Some 85 per cent of the farms, however, are credited with using electricity.

APPLICATIONS OF ELECTRICITY IN SWEDISH AGRICULTURE

Two demonstration farms were visited in Sweden, near Stockholm, where practically everything in the barn was electrified. At harvest time the grain bundles as they were brought in from the field were lifted from the wagon by an electrically operated hay fork and fed into a built-in electric motor-driven thresher. Straw was blown out into the yard or into the mow by an electrically driven blower. The threshed grain passed through a cleaner operated by electricity, and was conveyed to the various bins by the same power. A high-pressure blower blew the grain from the bins through spouts to a grinder and feed mixer, from which the feed was conveyed to an overhead bin and thence to the feed room. One blower was so arranged that it could blow air for ventilating the barn or for drying grain or hay in a built-in drier. There were milking machines, water pumps, and water warmers, all electrically operated; also a device to accelerate cooling of milk in cans in the cooling tank by rotating the cans back and forth through 180 degrees. Nearly 2 degrees F reduction per minute is claimed for this method. A slatted endless-belt drag to move manure from behind the cows into a pit was electrically driven, as were the hay chopper and a blower for blowing the hay into the mow. There were three such dairy farms, of different sizes, in operation in the Stockholm region.

Dr. Nils Berglund of the Altuna Machinery and Testing Station at Upsala, Sweden, estimates that 50 per cent of the farms in his country use electricity for various farming operations, and that 10 per cent additional use it for lighting only. Threshing is done commonly with electricity and very frequently with motors of 30 hp. Another use of this power is in connection with dairy equipment, including steam sterilizers. Electric hotbeds are found mainly in greenhouses in the larger cities. Cost of electricity averages about 2.5 cents per kwh.

England has probably the most complete network of electric power lines for agricultural service in Europe, and some 85 per cent of the agricultural land is served with electricity. Serious attention is being given by some companies to the use of underground cables, especially for conducting current across fields. A type of mole plow is used for burying the cables. While I have no figures as to costs of line construction, it is stated that cable installations compare favorably with overhead lines in this matter.

At Rothamsted, which I believe is credited as being the oldest agricultural experiment station in the world, tests have been made as to comparative costs of gasoline and electricity in driving a thresher, a feed grinder, and other farm machines. The results with an English make of thresher indicated the costs on a commercial farm would be roughly 32 cents per hour with the electric motor and 40 cents with the tractor, based on a cost of about 3 cents per kilowatt-hour for electricity and 12 cents per imperial gallon for kerosene, the same labor charge in both cases, and the life of a tractor as 8 years, of an electric motor as 20 years, and of the power lines as 25 years. Considerable study has been given in England to the use of electric motors, particularly portable types, and several unique types have been developed. One of interest is the so-called "Drumotor", consisting of a 5-hp motor housed within a drum about 24 in in diameter, which has a 3 or 4-in flange at each end upon which it is rolled from place to place. A folding bracket holds the machine in position when in use. A two-step pulley projects from one end. The push-button control with necessary protective devices is mounted in the central part of the drum, and the power cable is wound around the drum when the motor is not being used. The frequency of the current is 50-cycle, which probably is the same as that used in most European countries. Dairy equipment is being given very careful study and efficient steam sterilizers have appeared on the market. Use of electricity in poultry raising is proving important, and much attention is being given the subject of safe farm wiring.

VOLTAGE GRADIENT HAZARD OF GROUNDED NEUTRAL SYSTEMS

The rural electric department of the Agricultural Engineering Institute at Oxford, among other things, acts as intermediary between electric companies and farmers. One point raised by Mr. Brown of that department, and one which previously I had not heard discussed, is that of hazards to animal life from the voltage gradient due to leakage of current. He states in part in a recent letter, "One potent danger in many respects, is that due to the potential gradient created in the ground as the current leaks from the earth pin or spike through the ground back to the transformer. I am referring, of course, to the conditions such as we have, where the neutral wire is earthed at the transformer and where the earth resistance is appreciable, that is, 8 ohms or so. The irony is that the better the earth at the transformer end, the more of the potential drop is sent back to the consumer's end and the steeper is the gradient there".

A large number of tests in this connection have just been completed by Mr. Brown who states that a report will be published early next year. I am wondering if any one had noted similar phenomena in that connection in the United States. It is deemed of sufficient importance over there, at least, to justify the development of an earth-leakage circuit breaker, which is on the market.

In general, it seems that about as many different applications of electricity for agricultural purposes are being made in Europe as in the United States, but that the most extensive power consumption is for motor drives. Some of their problems are the same as ours, such as development of lower-cost line construction; development of suitable farm wiring methods, and of means of convincing the farmer that good wiring is necessary; simplification of rates schedules, which now vary from a simple statement to very complicated discussions involving calculations that no farmer or other layman can understand. The subject is very much alive, and great progress is being made as is evidenced by the high percentage of farms electrified. Progress has been especially rapid during the past ten years.

As a closing thought, I am wondering how closely our rural electric engineers are working with those abroad, and whether the Rural Electric Division of our Society cannot promote a closer relationship that would be to the mutual advantage of European and American agriculture.

Removal of Spray Residue from Apples

By R. H. Reed

FOR the apple growers of Illinois, the problem of meeting the federal tolerance[1] on lead residue became serious during the fall of 1933. Regulations regarding arsenic residue had been passed some years previously and much had been said and written regarding their enforcement. As so often happens in such cases, the growers thought, or more probably hoped, that the regulations would not be enforced. In any event, they were not prepared to meet the problem when it finally arrived.

As is so often the case, research work was started at a time when the solution of the problem itself was badly needed. In the meantime help was looked for where help was available, the Pacific Northwest. In that area washing had been carried on for a number of years, and much experience and knowledge had been gained.

In our case, however, the use of their knowledge, without questioning the conditions under which it had been obtained, cost some apple growers in Illinois large sums of money. Not until warehouses in states bordering Illinois were doing a considerable business storing seized apples was it discovered that sodium silicate could not be used, except as a preliminary wash, for apples which had been sprayed with lime, lime being a common ingredient in the sprays used in Illinois.

In this brief paper no attempt will be made to present the complete results secured at the Illinois Agricultural Experiment Station in its projects on residue removal. The object of this paper is to present the basic results secured in the projects and, in addition, some of the methods used and results obtained which could not be included in the regular publications.

Chemical Studies. Dr. W. A. Ruth and Dr. K. J. Kadow, of the department of horticulture, University of Illinois, started work on the residue removal problem in 1933. It soon became apparent to them that residues could not be satisfactorily removed by chemical or mechanical means, unless the washing solution was maintained at a uniform temperature. It was also found that, under many Illinois conditions, the tolerance could not be met unless the solution temperature was near, or at, the maximum permissible. This led to the establishment of a cooperative project between the departments of horticulture and agricultural engineering, a project cooperation which led to mutual exchange of ideas, encouragement, and help, and not simply to the division of administrative responsibility.

Results of the studies of Drs. Ruth and Kadow and D. S. Brown indicate that, during the weathering process, the lead-arsenic ratio in fruit residue remains almost constant at the proportion present in lead arsenate. Their results also indicate that, within limits, any washing treatment will remove a fairly definite percentage of whatever residue is present. The washing treatment is yet to be found which will remove any possible residue load above a certain fixed amount. The growers' washing problem would be greatly simplified if a treatment of this nature, which would reduce the residue below the tolerance, was available.

Present feasible methods effect a maximum residue removal of approximately 96 per cent of the residue load. If the tolerance of 0.018 grains of lead per pound of fruit is thus to represent 4 per cent of the original residue load, it is evident that, even with no factor of safety, the load could not be greater than 0.45 grains per pound. The growers who have residue loads above this amount face a difficult situation. It is likely that the solution of their problem will involve a change in their spraying program rather than one in their washing program.

In general, the results just referred to have indicated that a 1.25 per cent hydrochloric acid solution gives the best results. Higher concentrations have removed slightly more residue, but the relative effect of additional acid was small in comparison with the amount added. In an under-brush-flood type washer the 1.25 per cent acid solution at 70 F (degrees Fahrenheit) removed all but approximately 17 per cent of the residue, whereas at 110 F it removed all but about 9 per cent of the residue. Where just enough vatsol[2] was added to the acid solution to cause foaming, the removal was normally about the same as for acid alone. If the vatsol was increased to 0.5 per cent (dry basis) and $\frac{1}{3}$ gal of defoamer added to each 50 gal of solution to prevent foaming, only about 12.6 per cent of the residue remains after washing at 70 F, and only about 5 per cent after washing at 110 F. This proved to be an important finding, since it had seemed illogical to create a foam and then subdue it. In order to understand this situation more thoroughly, a series was run, using 1.25 per cent acid plus $\frac{1}{3}$ gal of defoamer per 50 gal of water. At 70 F this solution left about 26 per cent of the residue, and at 110 F, about 12.6 per cent. Thus we have the peculiar situation in which a defoamer improves the action of acid and vatsol, even though its action, when used alone, was detrimental. These results are presented in more complete form in Table 1.

It has been pointed out that sodium silicate cannot be used in a single-process washing program if the fruit has been sprayed with lime. This would appear to indicate

AFTER WASHING

ORIGINAL RESIDUE LOAD	70°F				110°F				TREATMENTS
	TREATMENTS								A HCl-$1\frac{1}{4}$%
Grains/Lb	A	B	C	D	A	B	C	D	B HCl-$1\frac{1}{4}$%
.203	14.8	16.8	14.3	26.1	6.9	8.4	4.4	13.3	VATSOL-TO JUST FOAM
	17.7	14.8	8.4	21.2	7.4	12.3	3.9	10.3	C HCl-$1\frac{1}{4}$%
Av.	16.2	15.8	11.3	23.6	7.2	10.3	4.1	11.8	VATSOL-$\frac{1}{2}$% DRY
.144	17.3	13.9	12.5	26.4	10.4	9.7	6.2	14.6	DEFOAMER-$\frac{1}{3}$G/50 G
	17.3	14.6	14.6	29.9	10.4	9.0	5.6	12.5	D HCl-$1\frac{1}{4}$%
Av.	17.3	14.2	13.5	28.1	10.4	9.3	5.9	13.5	DEFOAMER-$\frac{1}{3}$G/50 G

Presented before the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 2, 1936.

Author: Instructor in agricultural engineering, University of Illinois. Assoc. Mem. ASAE.

[1]The federal tolerance in effect at the present time is 0.018 grains of lead, 0.01 grains of arsenious oxide, and 0.01 grains of fluorine per pound of fruit.

[2]Vatsol is a mixture of the sodium salts of isopropyl and butyl naphthalene sulfonates. It was developed for use as a wetting agent in the textile industry. The chemical or mechanical action by which it displaces the surface air film and causes the surface to become wet is not known.

that the silicate should be used in the secondary tank of dual-process washers. Studies have indicated that the best results in Illinois were secured when the silicate was used in the primary tank and the acid was used in the secondary tank. No definite explanation has been found for these apparently contrary results. At the time the tests were made, it seemed that the silicate softened or removed the wax, and thus permitted the acid solution a better opportunity to reach the residue.

Some comparisons have already been given of the relationship of the temperature of the washing solution to the amount of residue remaining on washed apples. Dr. Ruth and Mr. Brown have results of tests made at 40, 70, 90, and 110 F. In plotting the results of individual temperature series, the curves were found to be somewhat irregular. When the results of all series and all treatments were averaged, the points all fell very nearly on the straight lines shown in Fig. 1.

The curve, temperature (X) versus per cent of lead left after washing for 0.5 min in a flotation washer (Y) was found by calculation to be

$$Y = -0.251X + 60.94$$

In the same manner, the curve for underbrush-flood type washers was found to be

$$Y = -0.253X + 44.12$$

Considering the fact that the basic data is an average of various treatments, it is logical to simplify the above equation into

Flotation washing

$$\text{per cent of lead left} = -\frac{\text{Temperature (deg F)}}{4} + 61$$

Underbrush-flood washing

$$\text{per cent of lead left} = -\frac{\text{Temperature (deg F)}}{4} + 44.$$

Analyzing these equations, we find that for each 4 F increase in the solution temperature, one per cent less residue remains on the washed fruit. The difference of 17 in the Y intercepts indicates that the underbrush-flood process leaves 17 per cent less residue on fruit than the flotation process using the same temperature and length of treatment.

Heating Requirements. A study of the problem of heating the washing solution in an apple washing machine indicated two major problems: (1) To determine the amount of heat required; and (2) to work out the design of suitable heating systems. The problem of finding a suitable acid-resistant material for use as heating coils was added later.

The following variables were found to govern the amount of heat required to maintain the washing solution of an apple washing machine at a constant temperature: (1) size and shape of the washing machine, particularly the solution tank, (2) type of washing process, (3) length of immersion time, (4) solution temperature to be maintained, (5) air temperature, (6) incoming fruit temperature, and (7) size and shape of the apples.

With the above variables, it was apparent that any routine heat requirement tests made during actual operation would be drawn out, could hardly be justified, and would be far beyond the finances available. In addition, general conclusions could not be drawn from tests made at other than the conditions to be used as a basis of design, since the heat given off by the washer and that absorbed by the apples follows different basic laws. For example, a heat loss test made using an immersion time of 30 sec would give no accurate indication of the heat required at an immersion time of 20 sec, since the test would not indicate how much of the heat went into the apples themselves.

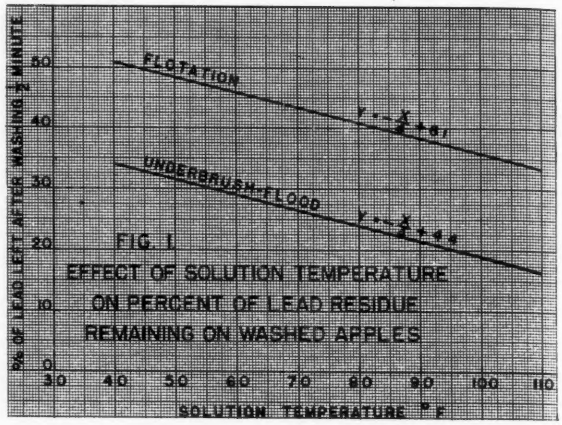


FIG. 1 EFFECT OF SOLUTION TEMPERATURE ON PERCENT OF LEAD RESIDUE REMAINING ON WASHED APPLES

It is undoubtedly true that the presence of apples in a washing machine changes the flow of the solution to some extent. This change would probably cause the total heat loss to be somewhat different than the sum of the heat lost by the washer and that absorbed by the apples when determined separately. However, the advantages of separate determinations far outweigh the disadvantages and, in addition, the values check remarkably well with those obtained during actual operation.

Washer Heat Loss. The heat given off by a liquid surface is proportional to the difference in temperature between the liquid and the surrounding atmosphere. The ideal method for obtaining the heat loss from a liquid is to immerse electrical heaters in the liquid until the temperature becomes constant. At this temperature the electrical heat input would equal the heat loss. The unit heat loss per square foot of tank area per degree Fahrenheit difference in temperature between the liquid and the outside air per hour, could be calculated from the equation

$$3.41W = CA\ (t_1 - t_2)$$

in which W denotes the watts input, C the unit heat loss in Btu per square foot per degree Fahrenheit per hour, t_1 and t_2 the solution and air temperatures in degree Fahrenheit, and A the exposed liquid surface of the tank in square feet.

In our particular case, suitable electrical heaters were not available. In addition, it was desired to test various washers in the field where suitable electric lines would be the exception rather than the rule. Consequently a slightly different technique was adopted. The solution was heated by any convenient method and then allowed to cool down while the washer was in operation, but without apples being washed. Temperature readings were taken at intervals over a period of time. In this case a somewhat similar equation was used

$$P\ (t_3 - t_4) = TCA \left[\frac{(t_3 + t_4)}{2} - t_2 \right]$$

in which P denotes the pounds of solution in the tank, t_3 and t_4 the temperatures of the solution at the start and end of the cooling period in degree Fahrenheit, and T the length of the cooling period in hours.

Table 2 gives the results of the tests made to date on all but two general types of washers. One type has not been available for test. The other type is of local manufacture and has been changed so frequently that tests have little significance.

TABLE 2. HEAT LOSSES RECORDED IN TESTS ON APPLE-WASHING MACHINES

Model	Type	Dimensions of acid compartment: Tank Width, in	Tank Length, in	Tray Width, in	Tray Length, in	Exposed surface area sq ft	Washer heat loss Btu/hr/deg F Total	Per sq ft
USDA	Flotation	34	171			40.3	230.3	5.7
Z	Flotation with pump	24¼	109			18.4	291.8	15.8
Exp'l*	Underbrush with pump	23¾	49¼			8.1	288.1	35.5
A	Flood	49½	54			18.3	751.5	41.1
C	Flood	60½	41⅝	57¼	43	34.6	1 110.0	32.1
D	Flood	66	48	62¾	61½	48.8	1 326.6	27.7
E	Underbrush flood	45	39¼			12.3	915.5	74.6
H	Underbrush flood	56½	81½			31.9	1 794.8	56.3

*Not a commercial model, but a small experimental machine.

Heat Absorbed by Apples. The calorimeter method was naturally the first to be considered for determining the amount of heat absorbed by apples in passing through a washing machine. Those who have had experience with this method know the difficulties involved in devising a technique suitable for the determination of small amounts of heat.

To obviate the need for using a calorimeter, an entirely different technique was devised. It was decided to measure the actual temperature increase in an apple being washed, and from this increase to calculate the absorbed heat thus represented. For this purpose a fine wire thermocouple imbedded in a thin glass tube filled with ambroid cement was used. Certain precautionary measures were necessary, such as imbedding the couple in the apple in such a way as to bring the junction in close proximity to an unbroken surface, and minimizing as far as possible the conduction of heat into or away from the junction by the couple itself. To accomplish this last, the following means were employed: (1) Fine wire, (2) protective tubes drawn as thin as possible, particularly at the end, (3) apples well-rounded in the area adjacent to the couple, (4) very short couple junctions, and (5) at least ½ in of apple separating the couple wires, where they emerged from the apple, from contact with the liquid. After making the necessary temperature readings, the apples were cut open and the exact location of the couple junction measured.

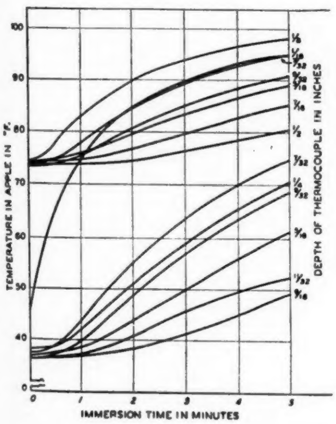
The chief advantage of the method adopted proved to be the ease of obtaining readings over a wide range of immersion times. Thus the temperature readings taken every 15 sec for 5 min, or practically as fast as a potentiometer could be balanced, read, and recorded, gave data for any possible length of washing period. The results are given in Fig. 2.

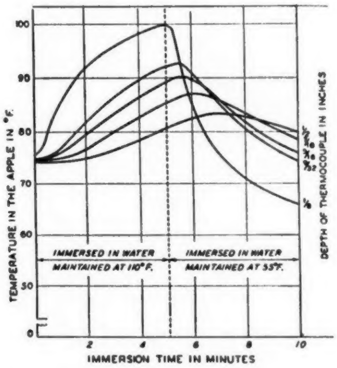
In translating these temperature readings into Btu per bushel, some consideration had to be given to the size, shape, and specific heat of actual commercial apples. In the interests of time economy, it was decided to strike as near average values in considering these variables, as possible. Thus it was arbitrarily assumed that average orchard run apples were spheres, 2.5 in in diameter, and composed entirely of water. This last assumption may seem far-fetched, but in reality is the most logical of the three. Since the water content of apples is high, the specific heat could hardly be appreciably lower than that of water. In addition, the specific heat, or the related factor, the coefficient of conductivity, had already entered into the calculations in its effect on the rate of heat penetration.

Cooling. The question arose early as to what effect the washing of apples in hot solution would have on their keeping qualities. It was known that washing, to be effective, required the removal of at least a part of the natural wax protective coating. In seemed likely that apples deprived of their natural protection, and containing an appreciable amount of unnecessary heat, were in condition to deteriorate rapidly. Dr. Ruth, Dr. Kadow and Mr. Brown have secured and will publish results on the storage of apples washed under a great variety of conditions.

Unfortunately the investigation into the amount of heat remaining in apples after washing and rinsing was limited by the time allocated to the project. A number of the apples used in studying the heat absorbed during immersion were transferred at the end of the 5-min "washing period" into cold water. Temperature readings were continued for a 5-min "rinse period." The results are given in Fig. 3.

Although these results are very meager, it can be concluded that the fresh water rinse given washed apples has advantages in addition to the removal of the residual acid solution. The rinse section in present-day washers is approximately half as long as the washing section. It seems likely that the washer of the future will contain a rinse section as long as, or possibly longer than the washing section. Such a change would remove more heat from the apples, as well as provide a more thorough rinsing.





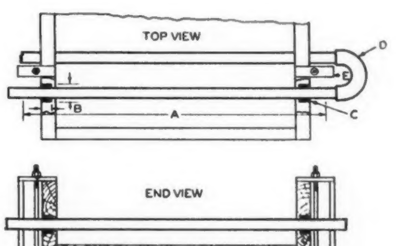


FIG. 2 (LEFT) RATE OF HEAT PENETRATION IN APPLES IMMERSED AND AGITATED IN A WATER BATH MAINTAINED AT 110 F. FIG. 3 (CENTER) TYPICAL SET OF HEATING AND COOLING CURVES FOR APPLES WASHED IN HOT WATER AND RINSED IN COLD WATER. FIG. 4 (RIGHT) CROSS SECTIONS OF WOODEN SOLUTION TANK, SHOWING METHOD OF INSTALLING PAINTED, GLASS-COATED, AND ALLOY METAL PIPES THROUGH THE WALLS

Designing the Heating System. In most cases the actual design of the heating systems was a more or less routine matter. The Guide published each year by the American Society of Heating and Ventilating Engineers contains all the necessary heating data, as well as information from which the necessary design factors can be selected.

A deviation from normal practice in the design of gravity-flow hot water heating systems may be of interest. Industrial buildings and houses are designed without particular reference to the heating system to be used. This requires that the heating pipes be selected so that their resistance to flow is equal to the pressure head available by reason of the actual depth of the basement. In fruit-packing sheds, on the other hand, a basement is not normally constructed, unless required for some special purpose. This situation seemed to call for a type of presentation in which the grower could select a heating system using a large pipe and a shallow basement or one using a smaller pipe and a deeper basement. Each design was therefore worked out for several sizes of pipe. Only the two or three sizes were presented which appeared to give a reasonably economic installation.

One Illinois fruit grower doubted the fact that hot-water heating systems worked according to known laws. In his case it would have been inconvenient to install his heater below the washer. To obviate this necessity, he discussed the matter with a salesman in a chain store in St. Louis and was assured that their heaters were not subject to the limitations we had imposed. In talking with this man later it seemed that there had been considerable excitement the first time the new heater had been fired up. The fireman claimed that when the black figures on the pressure gage turned red he had considered it time to leave, and did. It is extremely doubtful, of course, whether any such change took place, although it is certain that a heater, set on a level with the coils to which it supplies heat, would become hot enough to appear dangerous.

This grower, incidentally, has furnished the only actual proof yet known that the selection of a temperature as low as 40 F (his experience would indicate 32 F) for the air and apples entering the washer was correct for Illinois conditions. In his case, and he lives in the southern half of the state, it has repeatedly been necessary to chip the ice off the washer tanks before starting washing in the morning. This case was cited to a coworker as proof of the need for designing heating systems for a low air and fruit temperature. His reaction was that, if the heater were stoked all night, the solution would never freeze.

Something may well be said regarding the special types of steam heating systems worked out in some other states and our reasons for discouraging their use in Illinois. These heating systems are of various kinds, but in general involve the use of superheated live steam, under fairly high pressures. These pipe-flash superheating steam boilers would undoubtedly prove to be both satisfactory and safe under Pacific Coast conditions. There washing is done in large cooperative packing sheds and adequate technical talent can be hired. In Illinois, however, the custom is to hire some boy, who probably has never even lived in a house with a central heating plant, to act as fireman. Under these conditions, we have felt it desirable to advise against the use of even the ordinary live-steam systems using relatively low pressures.

Acid-Resistant Pipe. Some type of acid-resisting metal or metal coating is required if a heating system other than live steam is to be used. This material must resist the hot acid for a reasonable length of time. In addition, it must be available at a cost which the rather hard-pressed fruit growers will pay. Finding such a material has proved more difficult than might be expected.

An investigation into the general problem disclosed that at present it is impossible to predict the exact behavior of a paint, metal, or alloy, when immersed in hot acid. This situation is only in part due to the commercial attitude of certain manufacturers. If such problems are eventually to be solved empirically, if not rationally, it is desirable that publicity be given to the results of all tests, no matter how limited nor how special their application.

Many paints are resistant to either acid or heat, but a 1.25 per cent hydrochloric acid solution maintained at 110 F appears to be particularly destructive, both to the paint and to the manufacturers' promises. The destruction to the paint is particularly rapid when the pipes upon which it is placed carry steam at 210 F or higher temperatures.

New acid-resisting materials and a new technique were deemed necessary after two preliminary runs had resulted in the failure of a large number of special paints. These preliminary runs brought out the following facts even though the conditions under which they had been made were less severe than ordinary washer service:

1 Most so-called acid-resistant paints will not stand up under apple washer heating service.

2 It is practically impossible to protect pipe threads by an externally applied coating.

3 Small, sharp surface irregularities on the pipe must be removed.

4 Cast iron and galvanizing do not provide a suitable bonding surface.

5 Painted pipes extending above the liquid surface fail rapidly at that point.

Certain metals do not evolve hydrogen from an acid solution and are therefore acid resistant. The electrochemical series indicates this property by the relative location of a particular element with reference to the location of hydrogen.

Several common metals are listed below hydrogen in the electrochemical series, but most of them, such as gold and platinum, are too expensive to be used for pipe. The relatively cheap metal, copper, is next below hydrogen in the series and therefore not indicated as being very resistant to attack by acid. It was nevertheless included in the third series of tests.

Nickel is the third metal above hydrogen in the electrochemical series. It would be assumed for this reason that it would not be acid resistant. An alloy of 70 per cent nickel and 30 per cent copper (monel metal) has been used in the West with fair success, and is known to be quite resistant to acid. A monel metal specimen made up to standard pipe specifications was included in our third series of tests.

It is well known that glass resists the attack of most acids very satisfactorily. The use of glass tubing for heating coils did not appear to be feasible, however. The danger of breakage would be considerable if the tube were made thin enough to have a reasonably satisfactory coefficient of heat conductivity. The Pfandler Company, of Rochester, New York, was therefore approached to determine whether a very thin acid resisting glass coating (enamel) would be feasible on the outside of an iron pipe. With this combination, the glass would give the necessary acid resistance and the pipe the necessary mechanical strength.

Last winter a third test run was made using nineteen of the paints which had shown the greatest promise in preliminary work, copper tubing, *(Continued on page 267)*

Results of Field Studies of Small Combines

By W. M. Hurst and W. R. Humphries

FOR the purpose of this discussion, the term "small combine" refers to 5 and 6-ft power take-off machines. Considerable interest has been shown in this type of harvester because it is found in areas where combines have previously not been in common use; the machines are smaller, and the price is lower than for combines previously available. There are at the present time probably ten thousand of the 5 and 6-ft machines on farms throughout the corn belt, eastern, and southern states, the majority of which were sold during 1936.

With their introduction into these areas many questions arose, particularly as to adaptability, cost of operation, and performance characteristics. Reliable cost data can be obtained only after the machines have been in use sufficiently long to determine their average life, acres harvested annually, cost of repairs, etc. It was felt, however, that data dealing with performance characteristics of small combines would be helpful in determining to what extent these machines may be used, particularly in replacing binders in the corn belt and eastern states. With this objective, field work was begun by the Bureau of Agricultural Engineering in 1935 in cooperation with the agricultural engineering departments of the University of Illinois, Purdue University, and the Mississippi State College. During 1936 work was continued in cooperation with these institutions, and some assistance was given to the agricultural engineering department of Ohio State University on a similar study.

During the 1935 and 1936 harvest seasons, field tests were made on approximately fifty 5 and 6-ft and, for comparative purposes, on forty 8 to 16-ft combines, in harvesting wheat and oats. During the same seasons about forty small and twenty large machines were tested in harvesting soybeans. In making these tests, information was obtained as to field, crop, and weather conditions and as to cutter-bar and threshing losses, and in most cases samples of grain or beans were obtained for grade determination by the Bureau of Agricultural Economics. The procedure followed and type of equipment used in making field tests were the same as used in the past by state and federal agencies.

In making these field tests an attempt was made to determine the performance characteristics of the combines as operated by farmers. Unless there was something obviously wrong with the machine, no adjustments were made before it was tested for threshing and cutter-bar losses. If results showed high losses, the operator was informed and suggestions made as to adjustments to improve the performance of the machine. After adjustments were made, tests were usually repeated to determine their effect. It was also customary to make duplicate tests on each machine, even though operating in a satisfactory manner, to eliminate possible errors due to crop conditions or method of operation in the part of the field where the tests were made.

Harvesting Wheat and Oats. In 1935, wheat and oats in the corn belt were generally difficult to harvest. The straw was heavy and lodged, weed growth abundant, and the grain light, both as to weight per bushel and yield, on most farms. Under such conditions threshing losses—threshed and unthreshed grain thrown out with the straw and chaff—were high, with no significant differences with respect to size of machine. The small machines could, in general, handle a bulky crop infested with green weeds better than could the large ones, doubtless because of greater threshing and separating capacity per foot width of cut.

The 1936 small-grain harvest season in the corn belt was ideal for the use of combines. The weather was dry and hot, few weeds in evidence, practically no lodged grain, and the yield good in some localities. For these reasons, threshing losses were very low, even lower than would be expected with a threshing machine.

In harvesting wheat in Illinois in 1936, threshing losses for the small combines tested averaged less than 1.0 per cent, cutter-bar losses approximately 1.0 per cent, with a total loss of about 1.7 per cent. With 8-ft and larger combines, threshing losses approximated 1.3 per cent and cutter-bar losses 1.7 per cent, with a total loss of about 3.0 per cent. In oats, losses were considerably higher with all sizes of machines than in wheat during the 1936 season. With 5 and 6-ft combines, threshing losses approximated 2.7 per cent and cutter-bar losses 1.9 per cent with a total of about 4.6 per cent. Averages for the large machines approximated 5.0, 1.6, and 6.6 per cent respectively, for threshing, cutter-bar, and total losses.

In Indiana an insufficient number of tests were made in 1936 on wheat for comparing the performance of small and large machines, but in oats threshing and cutter-bar losses were larger for the 5 and 6-ft machines than for those of larger size. Threshing losses approximated 3.0 per cent, and cutter-bar losses about 1.0 per cent for the 5 and 6-ft combines, compared with 2.0 per cent threshing and less than 1.0 per cent cutter-bar losses for the larger ones.

Results of tests made in Ohio in 1936 in wheat show that threshing losses for the small combines approximated 0.6 per cent, and for the large machines about 1.0 per cent. Cutter-bar losses for the small ones averaged about 2.4, in comparison with 2.1 per cent for the large machines. Total losses were about the same for the two size groups, 2.9 per cent for the small and 3.1 per cent for 8-ft and larger.

Data obtained on ground speeds in harvesting small grain show that the small machines are generally pulled at a higher speed, indicating greater duty per foot of cutter-bar than with other sizes. In harvesting wheat in Illinois in 1936, the average speed of the small machines tested was 3.6 mph (miles per hour) and the large ones 2.6 mph. In oats, in the same state, the average speeds were 4.0 and 3.2 mph, respectively, for the two size groups. The data from Indiana show that the small machines average 3.5 and the large ones 2.7 mph. In Ohio, there was only 0.7 mph difference in speeds; the small ones averaged 3.8 and the large ones 3.1 mph in wheat. Under the crop and field conditions encountered in 1936, the small machines traveling at from 4 to 5 mph were saving as much grain as those traveling at 3 mph or less. However, under adverse crop conditions, high machine losses are usually associated with high ground speed.

Presented before the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, Ill., December 2, 1936.

Authors: Respectively, associate agricultural engineer (Assoc. Mem. ASAE), and chief engineering aide, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

(LEFT) HARVESTING WHEAT WITH A 6-FT POWER TAKE-OFF COMBINE. (CENTER) RETHRESHING STRAW IN MAKING A BLANKET TEST OF COMBINE THRESHING AND SEPARATING EFFICIENCIES. (RIGHT) A 6-FT POWER TAKE-OFF COMBINE WITH SACKING ATTACHMENT

Another point of interest in connection with machine losses for all sizes in wheat and oats is that threshed grain thrown out with the straw and chaff is usually much greater than that lost in unthreshed heads, frequently from two to ten times as much. From this it appears that the threshing unit on combines is more effective than the separating and cleaning units.

The quality of wheat and oats obtained with all sizes of combines was good in 1936. The moisture content was low, ranging from 7.8 to 14.2 per cent. Moisture was a grading factor in only one case and that was a sample containing 14.2 per cent. Results of analysis made of forty-one samples of combined wheat and thirty-four of oats, show that the grain was graded off in only four cases that could be attributed to the threshing and cleaning operations. In one case a machine was cracking some wheat, and adjustments eliminated the trouble. In two cases wheat was graded No. 2 because of foreign material, and in one case No. 3 for the same reason. The latter sample was also tough, with 14.2 per cent moisture which would have limited it to a No. 2 grade.

Harvesting Soybeans. In 1935, the latter part of the soybean harvest season in Illinois was wet and many fields of beans were not harvested until after January 1, 1936. Results of tests made during the early part of the season show no significant difference in threshing and cutter-bar losses for the small and large machines. In Mississippi, an insufficient number of large machines were tested in 1935 for comparing results with the small ones. However, the small machines could handle a bulky crop to better advantage and could be used on soft, wet ground where two or three tractors would be required to pull a large combine.

In Illinois in 1935, threshing losses for soybeans averaged approximately 2.1 per cent for the small combines and 3.8 per cent for the 8-ft and larger sizes, and cutter-bar losses approximated 7.2 and 6.1 per cent, respectively, for the two size groups, with little difference in total losses. Threshing and cutter-bar losses were higher in Mississippi in 1935 than in Illinois, the averages approximating 3.9 and 13.1 per cent, respectively, for the small machine. Threshing losses for the large machines averaged approximately 8.5 and cutter-bar losses 12.6 per cent, based on a limited number of tests.

The 1936 soybean harvest season in Illinois, where tests were made, was abnormal. A dry, hot growing season, followed by early fall rains and late frost, resulted in second growth and uneven maturity of the crop. Rains during the latter part of the harvest season also interferred with field operations, resulting in considerable weather damage to the beans, and shattering. Threshing losses on eleven small machines averaged 2.1 and cutter-bar losses 8.5 per cent, with a total of 10.6 per cent. On eleven 8-ft or larger combines, threshing losses averaged 2.3 and cutter-bar losses 3.9 per cent, with a total of 6.2 per cent.

The 1936 soybean crop was poor in the Mississippi Delta, due to dry weather, and considerable difficulty was experienced in locating fields with sufficient yield to justify harvesting with a combine. However, tests were made on seven small combines. For these, the threshing loss averaged 2.5, and the cutter-bar loss 7.1 per cent.

Analyses of samples of beans obtained in the corn belt and in the South, in 1935, favored the large machines in Illinois and the small ones in Mississippi. There was, however, considerable difference in concave adjustment in the small combines in the two areas. In the South, the bean plants were large and tough, and to handle the material it was customary to remove the concaves. As a result, fewer beans were split than in Illinois where the small machines were operated with the concaves in place, and at a slightly higher cylinder speed. Several small machines were found operating in Mississippi in 1935 in which less than 1.0 per cent of the beans were split and a satisfactory job of threshing obtained. In Illinois the range was from 1.5 to 18 per cent in 1935, but only a few samples were above 10 per cent, which is the maximum allowed for grade No. 2.

Six of the eight samples of beans obtained in Mississippi in 1936 graded No. 2, one No. 3, and one No. 4. The No. 3 sample was graded off because of foreign material and the No. 4 because of high moisture.

Of the twenty-seven samples of soybeans obtained in Illinois in 1936, fourteen were from 5 and 6-ft combines and thirteen from 8-ft and larger sizes. Of the fourteen samples, three graded No. 2; eight No. 3; two No. 4; and one sample grade. Of the thirteen samples obtained from large machines, two graded No. 1; four No. 2; five No. 3; and two No. 4. Splits were somewhat higher in samples obtained from the small machines than from the large ones in Illinois; three samples above 10 per cent were obtained from the 5 and 6-ft machines and only one for the 8-ft and larger sizes. The quality of the beans obtained in the South with small combines was higher than from the same size machines in the corn belt. However, in the South in 1936, as was the case in 1935, practically all machines were operated with the concaves out whereas in the corn belt the concaves were left in the machine, and, in general, a high cylinder speed maintained.

The ground speed in harvesting soybeans was somewhat greater with the small combines than with large ones,

approximately 3.7 and 3.2 mph, respectively, in Illinois in 1935. In 1936 in Illinois, the small machines averaged 3.5 and the large ones 2.8 mph. In Mississippi the average speed of the small machines tested in 1935 approximated 3 mph and the large ones 2.3 mph. Where crop conditions were favorable and the small machines traveled at from 4 to 5 mph, satisfactory performance was obtained in the corn belt and in the South.

CONCLUSIONS

1 In harvesting wheat and oats, threshing losses—grain thrown out with the straw and chaff—were somewhat lower for the 5 and 6-ft combines than for those of 8-ft and larger sizes. Cutter-bar losses, on the other hand, were slightly higher for the small machine, with very little difference in total losses for the two size groups. Available information shows no significant difference in the quality of small grain harvested with 5 and 6-ft machines in comparison with those of larger sizes.

2 In harvesting soybeans, as was the case with small grain, the 5 and 6-ft combines gave slightly lower threshing losses, but somewhat higher cutter-bar losses than the 8-ft and larger sizes. In 1935 in Illinois, the total loss for the small machine was less than for the 8-ft and larger sizes, but the reverse was true in 1936. In the South, with a limited number of tests, the quality of the beans obtained (U. S. grade) with 5 and 6-ft combines was slightly higher than obtained with larger machines. In Illinois the reverse was true, due doubtless to difference in machine adjustments for the two areas. The quality of beans obtained with a combine, especially with reference to splits, depends to a large extent upon cylinder speed and concave adjustment. Ample evidence is available to indicate that with proper adjustments a No. 1 or No. 2 grade of beans can be obtained with any size combine in good mechanical condition, provided the beans are not damaged prior to harvest.

3 The threshing unit in all sizes of combines tested appeared more effective in wheat and oats than the separator, as much more threshed grain was thrown over with the straw and chaff than unthreshed heads.

4 Small power take-off combines mounted on rubber tires are usually pulled at a speed of from 0.5 to 1.0 mph faster than machines equipped with an auxiliary engine and steel tires. Under favorable crop and field conditions the 5 and 6-ft machines will usually give satisfactory results when pulled at 5 mph, which is approximately twice as fast as the average speed of other sizes.

Removal of Spray Residue from Apples

(Continued from page 264)

and monel metal, glass coated (enameled), steel, wrought iron, and Cop-R-Loy pipe. The method of installing the pipe sections in the solution tank is shown in Fig. 4. This method provided a solution to problems No. 2, 4, and 5 given previously. The run was made under conditions practically identical with commercial operation, except that only one pipe carried steam at any one time.

Of the nineteen paint coatings tested, only two were found to resist destruction for a suitable period of time. Of these two, the XJ8219 bakelite vehicle mixed with aluminum powder gave the best results. This specimen was in the solution for a total of 59 days, during which time it was used for a heating coil for 10.25 days. It had not failed when the test was discontinued. The second paint, a XE7408 primer and XE3303 bakelite enamel, withstood destruction for a total of 41.75 days, during which time it was used for a heating coil for a total of 7.75 days. The excessive amount of xylol required to thin this enamel down from its bread-dough consistency did not seem logical. Correspondence with the Bakelite Corporation indicated that the enamel had probably deteriorated in storage and therefore might be expected to show up better than it actually had.

The copper tubing was found to have dissolved or flaked off to a considerable depth after a few days in the solution. A microscopic examination indicated that it had also become soft and spongy to a considerable depth below the newly exposed surface.

The monel metal pipe was submerged in the solution for a total of 41 days, during which time it was used for a heating pipe for 6.5 days. The pipe was found to be in good condition when the test was discontinued. A microscopic examination indicated that although some action had taken place it had been so slow as to be almost negligible.

The steel, wrought iron, and Cop-R-Loy pipes were completely eaten through in a very short time. The Cop-R-Loy pipe was found to be slightly more resistant than the other two pipes, presumably because of the finer grain resulting from the presence of even the small per cent of copper used in the alloy.

The enameled pipe was submerged in the solution for a total of 59 days, during which time it was used for a heating pipe for $3\frac{1}{3}$ days. At the time the test was discontinued it appeared to be in as good condition as when it had been received from the factory.

In a sense, the results thus far have been rather discouraging. Most of the paints which could be used to provide the cheapest type of heating coils, have failed. The two that have been satisfactory must be applied, handled, and installed very carefully. Monel metal and enameled pipe resist the acid satisfactorily but their relatively high first cost will discourage their widespread use.

A final series of tests is being made this winter. The two bakelite base paints, the monel metal alloy, and the enameled pipe are being given a further test. Additional paints will also be tried out. These are being supplied by companies which have been especially cooperative and whose paints have given some promise of being satisfactory.

SUMMARY

The University of Illinois has cooperated with the manufacturer and with the fruit grower in several ways in meeting the problems resulting from the establishment of fruit-tolerance regulations.

The agricultural experiment station has recently started an investigation to determine the amount of fruit spray residues which will prove dangerous to the human body. This has for its purpose obtaining exact information upon which the tolerance level can scientifically be based.

The department of horticulture has studied the effect of various washing solutions and types of washing machines on the amount of residue remaining on washed apples.

The department of agricultural engineering has obtained the necessary information for the design of suitable heating systems to maintain the washing solution at the required temperature.

What Agricultural Engineers Are Doing

Contributions Invited

All public-service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new development in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

FROM THE USDA BUREAU OF AGRICULTURAL ENGINEERING

S. W. McBIRNEY reports that germination stand counts have been completed on the sugar beet plots put in with the hill planter that is being developed to get more uniform seed distribution. The counts show that at the same seeding rate the new planter gives a significantly higher per cent germination stand than a commercial planter used for comparison. There is also an accompanying increase of one-third to one-half in the number of single seedlings, thereby permitting more rapid thinning.

Mechanical thinning of sugar beets is apparently feasible, according to McBirney. He notes encouraging progress toward this end with the experimental planters he and E. M. Mervine have built. Regular spacing of beet seed is accomplished by having the seed cells of the planter discharge individual seeds close to the soil. Unusually satisfactory rains this spring have permitted extensive experimental plantings.

* * *

J. W. Randolph reports that the large acreages of cotton planted by farmers in the Montgomery-Prattville, Ala., area with the variable depth planter have withstood the extremely adverse soil, disease, and weather conditions and have made stands, whereas with the customary planting methods there has been some replanting on 50 per cent of the farms. This makes the sixth season at the Prattville field that the variable depth planting method has proved successful on the 35 different types of seed beds.

* * *

Count von Bismarck, grandson of the famous German statesman Prince Otto von Bismarck, recently visited the division of mechanical equipment in Washington. He operates a large farm in northern Germany and is interested in mechanical equipment developments in the United States suitable for that region.

* * *

G. A. Cumings and D. B. Eldredge have completed the construction of special equipment used in fertilizer placement experiments on pasture and alfalfa in Indiana, Ohio, and Michigan. Furrows were opened 4 and 8 in apart. Considerable weight on the machine, as well as a relatively large amount of power, was required on bluegrass sod. In most cases sufficient phosphorus was applied to be effective for 4 or 5 years. An application of nitrogen and potash, which are soluble, can be made on the surface of the ground each year if desired.

* * *

The Central District drainage camps report the following work accomplishments for April: 5,322,591 sq yd of clearing, 1,396,017 cu yd of excavation and embankment, 34,215 lineal feet of tile reconditioning, and other miscellaneous work covering surveys and structures, requiring a total of 71,456 man-days.

* * *

Concerning his assignment to supplementary irrigation studies in the Dakotas, M. R. Lewis reports that the state water conservation commission of North Dakota has completed its organization and has worked out a program for the present season. In line with the policy of the commission to aid individual farmers and small groups in establishing irrigation systems, to date some 83 applications for preliminary surveys have been received. Twenty or more of these have been reported favorably and detailed surveys are under way. The other phase of the program is a cooperative effort, with the North Dakota Rural Rehabilitation Corporation, in developing small projects designed to furnish a small area of irrigated, forage-producing land for stockmen operating within a reasonable distance of the projects. The commission will be responsible for the engineering work on these projects. In South Dakota, programs for two preliminary surveys, one on supplementary irrigation and the other on stock water facilities, especially dams, have been worked out. An allottment of $25,000 has been made by the Resettlement Administration for loans to individual farmers for irrigation plants. Mr. Lewis, assisted by Carl Rohwer and Dean C. Muckel, will supervise these installations.

* * *

In connection with the study of irrigation of subtropical fruit in southern California, Colin A. Taylor reports that the wilting range determinations were completed and data are being plotted. A definite relation is shown between the proportion of root zone moistened and the minimum moisture content reached by the remaining unirrigated part of the root zone. These tests will show the degrees of water deficit developed by the plants without visible signs of wilting. Three mature orchards—a lemon orchard in San Bernardino County near Pomona, a navel orange orchard at San Dimas, and a Valencia orange orchard against the hills north of San Dimas—were selected for observation preliminary to a more detailed study of water deficit as it relates to growth rate of fruit and total yield. The plan of the experiment calls for two years of observation before any change is made in the irrigation, which will permit time to determine the varying needs of the trees and any difficulties in the way of nonuniform water penetration on each plot. The reaction of the trees over a period of years will be observed to determine what degree of water deficit is permissible without injury to the trees.

* * *

W. R. Swanson reported on May 1 for duty with the division of structures. He is a graduate of the University of Minnesota and at the time of his appointment was an instructor in agricultural engineering at that institution. After spending two weeks at the Washington office, he left with C. F. Kelly, for Hays, Kansas, where he will represent the Bureau on the wheat storage project. Mr. Kelly will spend a few weeks at Hays to help in getting the project started and will then go to Fargo, North Dakota, to carry on wheat storage investigations.

* * *

FROM THE UNIVERSITY OF GEORGIA

Adding materially to the physical plant of the college farm is the new $45,000 dairy barn which will soon be completed. All plans, specifications and supervision have originated from the personnel of the department. The barn utilizes genuine materials throughout, in addition to the most modern equipment, so as to meet the rigid, present day needs of the dairy enterprise.

The buildings included in the new unit are a central storage and feed processing barn, four silos, a sleeping and feeding barn, a combination milking barn and processing plant, a cow test barn and a calf barn. Each building may be considered a separate structure, although all are connected by arcades to facilitate management.

All of the buildings are of fire resistive construction having exterior walls of load bearing tile faced with stucco and carried on reinforced concrete foundations and footings. The floors throughout are of reinforced, waterproofed concrete. The milking barn will have quarry and ceramic tile floors and wainscots in the milking parlor, pasteurizing, and cooling rooms. The interior wall finish of all structures will be painted Portland cement plaster which can be easily cleaned by washing. Designed to carry twenty feet of baled hay, the mow floor of the central storage barn is of reinforced slab and girder construction. The roofs of all structures except the storage barn are constructed of specially designed steel trusses overlaid with a nailing concrete slab which, in turn, receives the finish roofing. All electrical circuits are carried in either rigid conduit or armored flexible cable. Screened steel casement windows admit an abundance of sunlight in all the structures. The four silos, 14x45 feet in size, are of reinforced monolithic concrete.

Lighting was given particular attention in the design of the structures. Glass steel diffusers were used in the animal shelters; vapor proof fixtures in the mow and R.L.M. reflectors in the storage barns.

Steel equipment characterizes the units throughout. A tandem stall arrangement with individual water fountains has been included. In the calf barn both individual and box pens have been provided. Automatic milkers, pasteurizing and cooling units, bottling machines, electric sterilizers, refrigeration units and a large automatic oil burning boiler with hot water tank have all been added to make the barn very complete and modern.

NEWS

Chemurgic Meeting Reflects Progress

DEFINITE progress, both in spreading the philosophy of farm chemurgy and in developing its techniques, was reflected in the Third Dearborn Conference of Agriculture, Industry, and Science, May 25 to 27.

Henry and Edsel Ford reaffirmed their sympathy with the movement by a complimentary luncheon at Dearborn Inn at the opening of the meeting. The balance of the sessions were held at the Statler Hotel in Detroit.

ASAE members attending included Earl D. Anderson, Theo. Brown, H. G. Davis, L. J. Fletcher, R. B. Gray, G. D. Jones, L. F. Livingston, Wheeler McMillen, Dr. Harry Miller, Arnold P. Yerkes, Col. O. B. Zimmerman, Frank, J. Zink. and possibly others. Mr. McMillen presided at the afternoon session May 25, and was toastmaster at the banquet May 26. Dr. Miller contributed a paper to the session on motor fuel from farm crops.

At the close of the first day's sessions, Dr. H. E. Barnard, director of research for the Farm Chemurgic Council, said conversationally, in substance, "It seems to me that speaker after speaker is pointing out agricultural engineering problems." Dr. Barnard was chairman of a symposium on new things in which several such problems were pointed out or reaffirmed. They included development of new and improved machines and methods for cultivation, weed control, harvesting, and decorticating flax and hemp; improved means of shelling tung nuts; a satisfactory harvester for perilla; and an improved harvester for sweet potatoes.

A cellophane covering for fruit and nut trees, which suggests the possibility of changing orchards from herbaceous nudist colonies into arboreal societies fully clothed for utility, if not for beauty, was reported by Dr. Wm. J. Hale as in process of development. Conservation of transpired water, insect control, frost control, and earlier maturity of fruit were some of the advantages he named as having been obtained experimentally.

R. B. Gray and L. F. Livingston held a joint luncheon meeting of their respective crop production machinery and farm processing committees. Organization for effective work was discussed at length. Several specific problems of growing and harvesting crops for industrial use at satisfactorily low cost were mentioned, and it was suggested that existing farm equipment be studied with a view to determining its suitability for new uses with little or no special adaptation, before active steps were taken to encourage the development of entirely new machines. The possibilities of preliminary farm processing of certain products to reduce the perishability of the material, and to minimize wasteful shipment of excess weight and bulk of water, dirt, and other material not desired in industrial processing, were discussed. The point of thus giving farmers additional profitable employment on their farms during slack field work periods was also mentioned. It was pointed out that farm processing equipment should be simple, largely mechanical, and should avoid the use of explosive or otherwise dangerous chemicals.

In the session on motor fuel from farm crops, progress was reported in solution of additional technical problems, in overcoming antagonism to the development, in lowering costs, and in securing wider distribution of the product of the Atchison, Kansas, pilot plant.

Throughout the conference repeated warnings were heard on the subject of keeping chemurgic development on a sound scientific footing, exposing dishonest and highly speculative promotion schemes, and avoiding promises to the public which might fail to be realized.

B. B. ROBB (RIGHT) PRESENTING HISTORIC JOHNSTON FARM TILE TO DR. C. G. ABBOTT (LEFT) OF THE SMITHSONIAN INSTITUTION

Tile Given to Smithsonian Institution

TWO lengths of the first farm drain tile used in America were presented to the Smithsonian Institution in Washington, D. C., May 4, by B. B. Robb, professor of agricultural engineering at Cornell University, "on behalf of the American Society of Agricultural Engineers, Cornell University, and the USDA Bureau of Agricultural Engineering."

Mr. Robb dug the tile from lines laid by John Johnston on his farm in Seneca County, New York, in 1835. The sections are horseshoe or U-shaped in cross section. They were taken from lines which, although laid more than 100 years ago, are still functioning.

Dr. C. G. Abbott, in receiving the tile for the Smithsonian Institution, showed knowledge and appreciation of the history, progress, and significance of tile drainage, born of his own boyhood experience in drainage on a New Hampshire farm.

Attending the presentation ceremony, in addition to Dr. Abbott and Mr. Robb, were F. A. Taylor and C. W. Mitman of the Smithsonian Institution, Wallace Ashby, Hobart Beresford, C. E. Gapen, F. R. Jones, L. A. Jones, S. P. Lyle, E. G. McKibben, and C. O. Reed.

The American Society of Agricultural Engineers commemorated, in 1935, the 100th anniversary of Mr. Johnston's first tile drainage experiments. It placed a bronze memorial tablet on a large boulder monument on the Johnston farm, and reviewed his life and drainage development in AGRICULTURAL ENGINEERING.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

IN spite of the fact that all engineers who have worked with and without maps are certain that vast economies can be secured in engineering operations if a knowledge of the terrain is available, mapping has not been officially accepted as an economy measure. In any event the economy program recently announced by the President does not include the request to Congress for $5,000,000 recommended for putting the basic mapping plan into effect by Secretary Ickes.

With the assistance of Dr. William B. Bowie, Council's surveys and maps committee and the many advocates of adequate basic maps for the United States have crystalized much sentiment into conviction in favor of inaugurating a real mapping program during the fiscal year beginning July 1, 1937. Many resolutions have been passed by engineering societies and by planning and scientific groups indorsing the mapping program, and it is a reasonable certainty that every Congressman and Senator has been informed by his constituents that mapping would be of an advantage to his state.

As a result it is doubtful if there is any sentiment in either the House or the Senate against the inauguration of a mapping program. Congress feels loathe, however, to inaugurate measures that involve the expenditure of money, and neither Congress nor the President have as yet become sufficiently convinced of the sound economic value of mapping to include it in their avowed economy program as basis for present and future public works activities.

It is of course possible that the President may reconsider his decision not to include the mapping of the country in his present program, but it is certain that he would not do so unless he is convinced that the public actually wants the mapping program initiated at once and is also convinced of very definite economies that would accrue in all parts of the country to having mapping undertaken at this time on a larger scale.

Council is not discouraged on account of the mapping situation, because it is of the opinion that the sentiment in favor of inaugurating the mapping program will be of sufficient magnitude to make it certain that the mapping *(Continued on page 272)*

ASAE Meetings Calendar

June 21 to 24, 1937—Annual meeting of the Society—University of Illinois, Urbana-Champaign

WHERE DOES POWER

Washington News Letter

(Continued from page 269)

will be started in the very near future. Since Council is designated to express the sentiments of engineers of this country, it feels obligated to keep engineers informed regarding this situation so that the reasons for delay may be understood and the appropriate action taken by those who appreciate the actual value of accurate maps and their public use.

Congress looks to the President to submit through the regular budgetary channel his recommendations regarding public works and therefore the immediate future for mapping work seems to be directly in the hands of the President. If he should be persuaded that the program should be inaugurated, there is good reason to believe that Congress would in this or its next session approve his recommendations.

The Geological Survey, the Coast and Geodetic Survey, the National Resources Committee and the Federal Board of Surveys and Maps, which is composed of representatives of all map users and map makers among government agencies, are on record with the President and the Congress urging the completion of an adequate mapping system as an essential foundation for the construction of public works at least expense and as a most desirable public assistance to private enterprise.

* * *

The Bureau of Public Roads and the Soil Conservation Service of the U. S. Department of Agriculture have announced the beginning of actual operations to protect highway cuts and fills, highway ditches, and drainage structures in Alabama, Arizona, Arkansas, Georgia, Idaho, Illinois, Indiana, Maryland, Mississippi, North Carolina, Ohio, Oregon, South Carolina, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin. Vegetative control measures will be used wherever possible, but construction work will be done where roadside gullies are menacing adjoining property. Under present plans, the Soil Conservation Service will furnish technical supervision, labor, and planting materials where the state will supply construction material and equipment, and agree to maintain the control work for five years after the planting or construction is done.

* * *

The Rural Electrification Administration had its second birthday on May 11, 1937. As of that date REA had approved 310 projects involving $58,952,958. Of that amount, about $56,862,958 will be used for line construction; $1,980,000, for building generating plants; and $110,000 for financing wiring and plumbing installation. Loan contracts have been executed for more than $45,500,000 of the allotted funds. Projects totaling about $32,000,000 have reached some one of the several stages of construction and according to REA enough wire has been strung on projects which it has financed to reach twice around the earth at the equator.

Some of the new REA procedures will be of interest to engineers in contact with rural electrification: Rural electric cooperatives are now required to use consulting engineering services. The cooperatives may also employ skilled management even before the lines are built and charge such salaries against REA loans until the project is completed and in operation. Help in building "Load" is being supplied by REA.

Student Branch News

Georgia Student Branch

THE Georgia Student Branch of the ASAE officially ended its year's activities at the regular meeting of May 24. Our organization has enjoyed a successful quarter under the leadership of the following officers: George Duke, president; W. L. Arrowsmith, vice-president; R. B. Stephens, secretary; and E. C. Mann, scribe.

We have had some very interesting programs during the quarter. J. P. Schaenzer of the CREA, gave a very enjoyable address on "New Uses of Electricity for the Farm." W. O. Collins, of the soils department, addressed the Branch the latter part of March on "The Relation of Soils to Agricultural Engineering." Among the several student programs was a debate on the subject "Resolved: That the Face-Out Method is Better Than the Face-In Method for Dairy Barn Construction."

The following students received honor keys for outstanding work in the Branch: Hamilton Clark, George Duke, and Henry Garrard. Hamilton Clark and George Duke were also successful in having their names engraved on the silver plaque for outstanding achievements in agricultural engineering. The year's membership in ASAE offered by the faculty of the department, will be divided between these two men.

The Georgia State Section of the ASAE held its spring meeting in Athens on April 17. Our Branch gave a dance honoring the engineers and their ladies who were in attendance. Our final social function was a barbecue on May 21 for all student branch members.

Approximately six thousand visitors attended "Livestock, Legume and Equipment Day," which was held on the college of agriculture campus May 6. Most of the student branch members assisted in entertaining these visitors. The greatest portion of our work consisted in preparing for and assisting in the machinery demonstrations.—*E. C. Mann, Scribe.*

Missouri Student Branch

Following is a report of the activities of the Missouri Student Branch for April and May.

April 16—M. M. Jones gave a talk on "The History and Use of the Slide Rule."

April 20—Farmer's Fair plans were made and discussed. The agricultural engineering float won third prize in the Farmer's Fair parade. We also had a large exhibit of modern farm machinery on display at the agricultural school's annual farmer's fair.

May 4—Plans were made for the annual banquet. Talks were made by Robert Sydnor, on "Baby Combines", and Joe Park on "Hydro-electric Plants."

May 18—Officers elected for the coming year were secretary-treasurer and scribe, Norman Teeter; vice-president, Vernon Wood; and president, Herman Hall. Talks were given by C. A. Kincaid on "Electrical Refrigeration," and H. J. Hall on "Greenhouses with Temperature Controlled Compartments."

May 25—Annual ASAE Student Branch banquet. The main feature was a talk by E. J. Gildenhous, from The Union Electric Company of St. Louis, who spoke on "Some Problems in Rural Electrification."—*Herman J. Hall, President.*

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Chester J. Acker, district sales engineer, Louden Machinery Co. (Mail) Box 21, Harrisburg, Pa.

Dee L. Bevans, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

Joseph H. Bodwell, rural sales supervisor, Public Service Company of New Hampshire. (Mail) 9 Prince St., Manchester, N. H.

Ralph J. Bugbee, agricultural engineer, Central Vermont Public Service Corporation. (Mail) North Clarendon, Vt.

Ray S. Carberry, assistant regional engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 464, Santa Paula, Calif.

Gerald M. Carter, agricultural aide—engineering—Soil Conservation Service, U. S. Department of Agriculture. (Mail) 62 E. Washington St., Gainesville, Ga.

Joe K. Cochran, senior assistant in soil conservation and assistant county agent, Collins, Miss.

M. D. Coons, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 144 Church St., Chillicothe, Ohio.

Ray Crow, engineer, sales promotion division, Tennessee Coal Iron & Railroad Co., Box 2634, Birmingham, Ala.

F. D. Dale, J. I. Case Co., Coldwater, Kans.

Ralph W. DeWeese, junior drainage engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

S. S. Hansen, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture.

Andy T. Hendrix, assistant professor of agricultural engineering, University of Tennessee, Knoxville, Tenn. (Mail) RFD 6.

Floyd B. Hillman, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) CCC Camp D-6, Delaware, Ohio.

Howard G. Ingerson, sales manager, John Bean Manufacturing Co. (Mail) 151 N. Harrison Ave., East Lansing, Mich.

W. Parker Ireland, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Box 224, Georgetown, Dela.

William H. Klingner, McCann Klingner, 520 W.C.U. Bldg., Quincy, Ill.

Herman C. List, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Cynthiana, Ind.

M. S. McNay, sales manager, Rockwood Manufacturing Co., 1801 English Ave., Indianapolis, Ind.

Carlysle Pemberton, junior civil engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Oakland, Ill.

Otis F. Reiter, experimental department, Fastpic Corporation, Baltimore, Maryland. (Mail) 2715 W. Lafayette Ave.

Frank J. Stablein, tractor engineer, Ethyl Gasoline Corporation. (Mail) 468 Morris Ave., Rochville Centre, L. I., N. Y.

James B. Stere, agricultural service division, West Penn Power Co. (Mail) 500 Kelly Ave., Wilkinsburg, Pa.

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A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

THE LABORATORY TESTING OF LUBRICANTS, *F. J. Slee.* Jour. Soc. Chem. Indus., Chem. and Indus., 54 (1935), No. 36, pp. 809-814. This paper presents a discussion of the commonly applied laboratory tests for lubricants and their interpretation in practice, and indicates what appear to be vital laboratory tests for each type of lubricant. Special attention is devoted to internal-combustion engine oils.

It is concluded that lubrication is not a science having mathematical precision and that laboratory tests are not strictly comparable with running tests. It is thought, however, that laboratory tests, where correctly conducted, are in many cases indicative of the results which are generally met in practice.

ALT'S HOUSE HEATING PLANS, *H. L. Alt.* Chicago: Dom. Engin. Co., 1936, pp. V + 208, figs. 100. Technical information is presented on the subject in this handbook, which includes especially data on the design of heating systems.

EFFECT OF ARTIFICIALLY DRYING SEED COTTON BEFORE GINNING ON CERTAIN QUALITY ELEMENTS OF THE LINT AND SEED AND ON THE OPERATION OF THE GIN STAND, *F. L. Gerdes* and *C. A. Bennett.* U. S. Dept. Agr., Tech. Bul. 508 (1936), pp. 62, pls. 3, figs. 13. Studies are reported, the purposes of which were (1) to show the relationship between the moisture content of seed cottons (undried) and some of the quality elements of ginned lint, (2) to determine the extent to which artificial drying, within a specified range of temperatures, reduces the quantity of moisture in seed cottons of different moisture contents and in the resulting ginned lint, (3) to show the comparative effects on certain quality elements of ginned lint and cottonseed, and on the mechanical operation of the gin machinery, produced by ginning seed cottons of different moisture contents without conditioning, and portions of the same seed cottons after artificially drying at varying temperatures, and (4) to determine the proper drying temperatures for seed cottons of different moisture content.

Sixty-nine American upland cottons selected from the 1931, 1932, and 1933 crops to represent a wide range of seed cotton characteristics were used, these being obtained from nine states including and extending from Georgia and the Carolinas to Texas. They varied in moisture content from 6.8 to 26.4 per cent, in staple length from 7/8 to 1-9/32 in, and varied widely in other characteristics.

Portions of the seed cottons, dried and undried, were ginned on new and properly adjusted brush and air-blast types of gins at constant saw speeds and with loose and tight seed-roll densities (slow and fast rates of feed, respectively). However, since the effects of drying were observed to be similar for the two types of gins, only the results for the brush type gin are presented.

The amount of moisture removed from seed cottons by drying at a temperature of 150 F increased with increase in moisture content on the average from 1 lb per 100 lb of seed cotton for those with less than 12 per cent moisture, to 3 lb for those having 16 per cent or more. The amount of moisture removed at the higher temperatures was only slightly greater than that at 150 F, presumably due to the relatively short period of exposure in the drier (15 sec) and to the fact that the relative humidity of the air heated to the higher temperatures is not appreciably lower than that at 150 F.

The greater part of the drying action on seed cotton is confined to the fibers. The amount of moisture removed from lint per 100 lb by drying at 150 F ranged from an average of 1.5 lb for seed cottons below 12 per cent in moisture to an average of 4 lb for those having 16 per cent or more, and increased slightly with higher drying temperatures.

The moisture content of seed cotton has a pronounced effect on the smoothness with which it is possible to gin the lint, successively lower preparation being associated with increases in moisture content. The unfavorable effects of ginning cottons with excess moisture are intensified as the staple length of the cotton is increased and as the seed-roll density is changed from loose to tight.

Average grade improvements, or the combined influence of generally smoother preparation and occasionally brighter color and reduced leaf, as a result of artificial drying, were more pronounced for the longer than for the shorter cottons. Drying at a temperature of 150 F showed grade benefits ranging, on the average, from about one grade for either length group having 16 per cent or more moisture to approximately one-third of a grade for the longer cottons having 8 to 11.9 per cent and the shorter cottons having 12 to 15.9 per cent moisture. Cottons having a moisture content below these respective limits did not show enough grade improvement to justify drying.

Staple length, on the average, was preserved when the seed cotton was dried at 150 F, but higher drying temperatures were in general accompanied by ginned lint with slightly shorter staple length as shown by classification and with increased variability of fiber length. In many cases drying temperatures above 200 F were associated with shortening of staple to an extent of 1/32 to 1/16 in.

Average fiber strength was not weakened by drying the tested seed cottons at temperatures up to 200 F, but there appeared to be a slight weakening of the fibers when the material was dried twice in succession at 250 F. The temperature of the hot air at the inlet of the drier should not greatly exceed 150 F, except for very wet cotton and then should seldom, if ever, exceed 200 F. The critical temperature is reached sooner with short-staple or lower moisture content than with long-staple or higher moisture-content cottons respectively.

Based on average grade and staple premiums and discounts at Memphis, Tenn., for the 1932-33 season, drying long-staple cottons of relatively high moisture, averaging 14 per cent, increased the average monetary value per bale about $3, or 8 per cent, when ginning with a loose seed roll, and $2, or 6 per cent, with a tight roll. Drying and ginning with a loose roll increased the average value of the same cottons approximately $7, or 20 per cent, as compared with that for corresponding portions ginned damp or wet with a tight seed roll. Long-staple cottons having an average of 10.8 per cent moisture showed increases in value from drying of over $3, or 10 per cent, when ginned with a loose seed roll, and $1, or 3 per cent, with a tight roll. Ginning portions with a loose seed roll after drying gave an increase in value of over $4, or 14 per cent, as compared with the value of the cotton obtained with a tight seed roll without drying.

With short-staple cottons of relatively high moisture, averaging 15 per cent, the average monetary value per bale was increased 67 cents, or almost 2 per cent, by drying when ginned with a loose seed roll, and 68 cents, or 2 per cent, with a tight roll. The value of these cottons dried and ginned with a loose seed roll was higher by almost $1.50, or 4 per cent, than that obtained when portions were ginned damp or wet with a tight seed roll. Shorter staple cottons, averaging 10.8 per cent in moisture, showed decreases in monetary value with drying.

The beneficial effects of artificial drying, as shown by the differences between paired samples, are considered as being probably of smaller magnitude than would have resulted had machinery been used in these experiments that was more or less worn out or obsolete, or inadequately repaired, or improperly operated.

The percentage germination of seed from portions of seed cotton dried at test temperatures was not reduced by drying; on the contrary, the dried portions show germination of slightly higher percentages.

An appendix presents basic tables showing absolute values of paired undried and dried samples.

THE ROLE OF THE CAPILLARY POTENTIAL IN THE DYNAMICS OF SOIL MOISTURE, *W. Gardner.* Jour. Agr. Res. [U. S.], 53 (1936), No. 1, pp. 57-60. This is a brief mathematical analysis.

DESCRIPTION OF HOMEMADE AIR COOLERS, *L. H. Mitchell.* Reclam. Era [U. S.], 26 (1936), No. 8, p. 196, figs. 2. Homemade air coolers are described which originated on the Salt River project of the Bureau of Reclamation during 1935.

The air cooler is made of a wooden box made to fit tightly in the lower half of a window, a bit of excelsior, a tin trough perforated to spread water through the excelsior, and a good-sized electric fan. The fan draws air through the moistened excelsior and in doing so lowers its temperature. The temperature of a room can be lowered 10 or 15 F with one of these homemade air coolers. *(Continued on page 282)*

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(Continued from page 274)

ELECTRICAL HEATING OF SOIL IN FRAMES, *C. P. Quarrell.* Jour. Min. Agr. [Gt. Brit.], 43 (1936), No. 5, pp. 446-452, fig. 1. The results of a conventional type of experiment on the use of electricity for the heating of soil in hotbeds are briefly presented. In this experiment it was attempted to simulate commercial green house conditions with early garden market crops, including lettuce and carrots.

Seven ranges, each consisting of 41 Dutch lights, were used in the experiments. Four ranges were heated by the electric cables and three ranges were retained as controls.

While the cables were laid at a depth of 8 in below the surface, the results of the experiment seemed to indicate that a depth of 5, or even 4 in would have been more effective without causing excessive drying out of the soil.

Under the conditions of the experiment the desired temperature of 60 F was reached only on sunny days and was not maintained for any length of time. Further fluctuations between night and day soil temperatures were considerable in the heated ranges.

Under the conditions of this experiment, electric power for the purpose of soil heating proved to be too expensive to be of commercial value. If it had been possible to provide thermal insulation for the frames, considerably higher temperatures would have been obtained. It is considered possible that the application of soil heating one month earlier in the year to these crops would give better results by reason of the higher market prices obtainable.

WEIGHTS OF SOUTH AFRICAN GROWN TIMBERS, *M. H. Scott.* Union So. Africa Dept. Agr. and Forestry Bul. 145 (1935), pp. 21, figs. 4. This is a practical type of publication which brings up to date data on the air-dry weights of South African timbers of economic importance.

FURTHER STUDIES OF THE LIMITS OF PHOTOSYNTHESIS, *G. R. Burns.* Vermont Sta. Bul. 402 (1936), pp. 16, figs. 3. The light sources used in this study were four 1,000-watt projection type lamps operated at constant ($\pm$ 0.2 per cent) voltage and placed at the four corners of a rectangle with the plants in the center, the lights and plants being at the same level. Light-filtering solutions (formulas given) were used to give red, yellow, and blue lights, respectively. Trees from 4-year-old nursery stock of white pine and Norway spruce, potted 2 months previously, were placed in small, cubical greenhouses glazed with infrared-red or blue-violet transmitting glass. After holding in the filter houses for 2 weeks or longer, they were taken to the laboratory and their photosynthetic efficiency in the infrared-red or blue-violet radiations relative to that in the middle portion of the spectrum was determined, the crown of each tree being sealed in a bell jar containing about 1 per cent CO_2, placing it in such an intensity of white light that the respiration was equal to photosynthesis, and determining the amount of CO_2 by gas analysis. Then the tree was placed under one of the colored lights for 2 hr, returned to the white light, and a second CO_2 analysis made. The light filters were then changed, and the run was repeated under a different colored light. Two trees were used in each run, so that the interval between the first and second runs was about 1½ hr. The uneven response of a tree to a given light color on different days was due in part to the fact that, while care was taken to see that the trees were in the same positions during each pair of runs, no attempt was made to see that the positions were the same on different days.

The results at the red end of the spectrum were uniform. Trees from the blue house used the red radiation less efficiently than those grown outdoors and much less so than those grown in the red house, and the longer the tree was in the blue house the lower was its efficiency in red light. The opposite was true for trees grown in the red house. The observed changes were larger than the experimental error. The figures for the blue end of the spectrum revealed no regularities, one reason perhaps being that the portion of the spectrum used in investigating this point was not particularly suitable. The total chlorphyll (on the wet weight basis) was 10 per cent higher in the pines from the blue house, while carotene and xanthophyll were about 5 per cent lower than those from the red. Speculations as to the cause of this change in efficiency are deemed perhaps idle on the basis of the data at present available. In the yellow light the plants were receiving about 10 quanta of light per molecule of CO_2 reduced, so that any increase in efficiency could as well be attributed to a better use of absorbed light of a given wave length. While it appears probable that the efficiency in the yellow light is constant and that the change is in efficiency in the blue and the red lights, it is possible that the efficiency in the yellow changed. The large changes noted at the red end of the spectrum, as well as their apparent regularity, point to the operation of a single, and perhaps discoverable, factor.

From the viewpoint of the short wave limit of photosynthesis it appears as though these two species were unable to use light in the blue-violet part of the spectrum, as well as that near the center of the visible spectrum, and the calculated limits of photosynthesis ranged from 448 to 467 mμ. Thus growing the trees under different lights had a slight and irregular effect on this limit. The comparisons between the sodium lights and the yellow light indicated that the former had an efficiency of 1.23 ± 0.04 with pine and of 1.24 ± 0.01 with spruce.

It is believed that the main reason for the higher efficiency of the sodium lights lay in the fact that the area of the source was about 100 times that of the incandescent lights. However, if photosynthesis depends on light absorption by chlorophyll a, this radiation, consisting largely of the two sodium lines near 590 mμ, would be handicapped.

A MECHANIZED PROCEDURE FOR DETERMINING THE STICKY POINT OF SOILS, *L. B. Olmstead.* 3. Internatl. Cong. Soil Sci., Oxford, Eng., 1935, Trans., vol. 1, pp. 5, 6. The author reports from the U. S. D. A. Bureau of Chemistry and Soils that "more nearly reproducible results were obtained when the spatula was replaced by a thin polished steel disk rotated at any desired speed through reducing gears by a small variable speed electric motor, the soil sample being held against the edge of the rotating disk. This device, although an improvement over the spatula, was not so satisfactory as was a smooth roller. The apparatus consists of a polished steel roller exactly 5 cm in diameter and about 15 to 20 cm long, mounted horizontally 3–4 mm above a movable flat steel plate, and rotated by a hand crank. A 15–20-gram soil sample, moistened and thoroughly kneaded, is placed on the plate and fed against the roller.

"The desired sticky point is reached when the soil just fails to stick to the roller at a prescribed shearing speed. This point can easily, repeatedly, and continuously be checked on each sample by varying the rotational speed of the roller. At higher speeds the sample sticks to the roller, and at slower speed the roller clears. By this procedure better agreement between replicate determinations has been obtained than by any of the other methods so far investigated. The greatest variations in results occur in silty soils low in colloid which are nearly nonplastic in the Atterberg meaning of the term and consequently nearly nonsticky. One is not troubled with the presence of a thin film of soil material on the roller, such as is often found coating the spatula blade. Neither is there the uncertainty which often occurs in the spatula test of how to interpret the appearance of the metal surface."

The author has thus far carried out the determinations at a shearing speed of 5 cm per second.

THE BINDING FORCES BETWEEN CLAY PARTICLES IN A SOIL CRUMB, *E. W. Russell.* 3. Internal. Cong. Soil. Sci., Oxford, Eng., 1935, Trans., vol. 1, pp. 26-29, fig. 1. In a contribution from the Rothamsted Experimental Station the author advances the hypothesis that clay particles are held together in a crumb by orientated molecules of a polar liquid. "This liquid was the dispersion medium in the paste from which the crumb was formed. These polar molecules lie between the negative charges on the clay surface and the exchangeable cations that have dissociated from the clay, and they are strongly orientated in the electrostatic field between these charges. The binding link postulated between two clay particles consists of three units—orientated molecules, an exchangeable cation, orientated molecules—and it binds a negative charge on the surface of one clay particle to a negative charge on the surface of a second. This hypothesis accounts satisfactorily for the main experimental facts concerning the hardness of crumbs and the conditions under which they are formed."

AIR TEMPERATURE IN RELATION TO FIRE COST AND DAMAGE, *L. G. Gray.* Jour. Forestry, 34 (1936), No. 8, pp. 779-785, figs. 2. Pointing out that temperature is a fundamental control of relative humidity (usually bearing an inverse relationship to it), and that temperature is also related to evaporation, precipitation, and wind movement, the author correlates temperature with fire data for all the California national forests combined and suggests that on a long-time basis there is an interesting, useful, and partial correlation between air temperature and economic fire factors.

A STUDY OF FARM REFRIGERATION METHODS. *E. Latzke and D. Berrigan.* North Dakota Sta. Bul. 286 (1935), pp. 72, 73. This progress report deals chiefly with the kerosene-operated refrigerators of the automatic continuous-burning and refueling types. *(Continued on page 284)*

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(Continued from page 282)

A Direct Method of Aggregate Analysis of Soils and a Study of the Physical Nature of Erosion Losses, *R. E. Yoder*. Jour. Amer. Soc. Agron., 28 (1936), No. 5, pp. 337-351, figs. 5. The "inherent weaknesses" of the elutriation method of aggregate analysis are pointed out, and the use of this method of aggregate analysis is questioned; a mechanism is devised to account for the slaking reaction of soils in the presence of excess water; and a method and apparatus for determining the water-stable aggregate distribution in soils are reported.

"Several soils of the Cecil series with widely varying clay contents were found to have similar distribution of water-stable aggregates. Soils from different series were found to be characterized by different distributions of water-stable aggregates."

The physical nature of the erosion process was studied on controlled field plats of Cecil clay located on several slopes. The losses from this "strongly aggregated" soil were found to occur primarily in the form of water-stable aggregates.

Data presented to show the effectiveness of winter legumes in controlling sheet-erosion losses are included, and the manner in which this type of "vegetative control" functions is reviewed. Results of the use of various widths of strip crop for controlling sheet erosion are presented. "The basic weakness of this type of vegetative control practice" is pointed out.

Combine Investigations with Spring Wheat and Oats, *H. K. Wilson*. In Proceedings of the World's Grain Exhibition and Conference, Regina, Canada, 1933. Ottawa: Canad. Soc. Tech. Agr., 1933, vol. 1, pp. 463-469; abs. in Minnesota Sta. Rpt. 1935, p. 14. Varieties of spring wheat and of oats were grown at the Minnesota Experiment Station in rod rows during the period 1930-32, which was unusually dry, averaging 4.4 in of rainfall below normal. Row harvests were made when the grain was considered in a proper stage for binder harvesting and at 4, 8, and 14 days thereafter, and harvested samples were threshed at once.

Each of the 14 spring wheats maintained yields throughout the 2 weeks. While most of the 12 oats varieties suffered reductions in yield, Anthony, a midseason oats, maintained its yield level throughout the trials and appeared most promising for combine harvesting. Grain quality, as evidenced by plumpness of both wheat and oats and texture of wheat, usually increased to 8 days after the normal binder harvest time. Since moisture conditions during the period were abnormally low for the station, the results probably were more nearly typical of those expected in dry farming areas of the Dakotas, Montana, and Canada.

Photoperiodic Responses of Certain Greenhouse Annuals as Influenced by Intensity and Wavelength of Artificial Light Used to Lengthen the Daylight Period, *R. B. Withrow and H. M. Benedict*. Plant Physiol., 11 (1936), No. 2, pp. 225-249, figs. 9. The plants used in these studies at Purdue University were pansy (Viola tricolor), stock (Matthiola incana), and China-aster (Callistephus chinensis); the intensities of incandescent lamp radiation were 100, 10, 1, 0.3, and 0.1 footcandles; and the wavelengths included blue (380–510 mμ), green (455–550 mμ), yellow (530–650 mμ), orange (650–? mμ), red (680–? mμ), extreme red (720–? mμ), and infrared (800–? mμ).

As to intensity, but little response differences were secured between 100 and 10 footcandles, and a very definite photoperiodic effect was induced by 0.3 footcandle and as low as 0.1 footcandle with China-aster. An increase in dry weight over the control was induced in all three species under all intensities of artificial radiation used. An increase in the top:root ratio also occurred in pansy and stock with increase in intensity.

As to wavelength, the orange and red caused the most marked photoperiodic response in all three species. The earliest blooming with pansy and stock and the most flowers with all three species occurred under these bands (especially the orange red), and in stock the greatest departure in branching habit. But little effect on flowering time occurred in pansy and stock under the blue, green, or yellow, but in aster all wavelengths of additional light induced earlier flowering. The top:root ratio in all three species was greater under all wavelengths, the greatest ratio occurring under the orange red. The fresh weight was also greatest under orange and red radiation.

The Removal of Fluorine Spray Residue from Apples Sprayed with Natural Cryolite, *K. Groves, R. E. Marshall, F. L. Overley, and J. L. St. John*. Washington Sta. Bul. 329 (1936), pp. 15. Stating that large amounts of fluorine compounds are now used in Washington apple orchards but that their use has been limited by difficulties in residue removal, the authors discuss the results of washing experiments with apples sprayed according to prescribed schedules and for the most part cleansed with the experimental machine developed by the college. Of 322 fluorine determinations, 178 were the results of three washes of five different samples. In one test in which samples in the same lot of sprayed fruit were washed on 7 different days and a total of 17 analyses were made, there was an average of 0.014 grain of fluorine per pound of fruit. The minimum was 0.008 and the maximum 0.025 grain per pound. Thus an average residue below the tolerance did not necessarily mean satisfactory cleansing.

A number of trials were conducted with aluminum chloride as one solution in a tandem with sodium silicate. The results were unsatisfactory, as the aluminum chloride apparently formed a gummy deposit on the surface of the apple wax and this deposit was not completely removed in the water rinse. There was no noticeable improvement when 1 per cent of mineral oil was added. Minor variations in the washing procedure, such as the use of brushes or rollers, changes in the sequence of the washes, or the addition of oil to the acid or to the sodium silicate, did not alter materially the results. Tandem washes with hydrochloric acid and oil as the first wash were not effective. Without the oil the data showed no advantage for either sequence for the hydrochloric acid. Apples washed in solutions containing mineral oil lost moisture and shriveled more rapidly in storage than those washed without oil. The authors point out that with one exception the spray programs followed were severe from the residue removal standpoint, yet in general they conclude that too much confidence should not be placed on one season's results.

Effects of Storage and Holding Conditions on Alternaria in Lemons, *H. S. Fawcett, L. J. Klotz, and H. W. Nixon*. Calif. Citrogr., 21 (1936), No. 4, pp. 118, 143, 144, figs. 2. Since Alternaria decay often causes serious losses in lemons held in cold storage, an experiment was conducted (1935) by the California Citrus Experiment Station in cooperation with the Fruit Growers Exchange. The results indicated that lemons from the air-conditioned, refrigerated storage room (lot A) were superior in keeping quality to those from the naturally ventilated one (lot B). After removal and placement in cabinets held at various temperatures, the lemons of lot A continued to show a greater resistance to *Alternaria* than those of lot B. The greater resistance to break-down was considered as due to the more constant temperature and humidity and to the smaller accumulation of deleterious substances, as indicated by the lower concentration of carbon dioxide in the air-conditioned room. From 59 F upward lot B showed a rapid increase in the fungus and in indications of its presence, while lot A did not do so until a temperature of 65 F was attained. The greater amount of *Alternaria* in lot B was correlated with a much higher percentage of black buttons after 6 months' storage.

The condition of the fruit when taken from storage thus appears to be a reliable indication of its later keeping quality.

Bruising in Harvesting and Handling Apples and its Relation to Spray Residue Removal, *E. L. Overholser*. N. Y. State Hort. Soc. Proc., 81 (1936), pp. 51-62. Observations in western New York on the bruises received by apples during harvesting operations showed a direct relationship to the firmness of the flesh. In certain tender varieties there were few bruise-free apples when the fruit reached the packing house. The individual who picked the fruit and the type of container used in picking were found important factors in bruising. In the washing machines the underbrush type washer caused considerable more bruising than did the flotation type. Driers with walk-over or shuffleboard types of conveyors were found to cause considerable bruising. Various suggestions are made as to better methods of handling fruit in the packing house and in storage.

Stationary Equipment for Orchard Spraying and the Manufacture of Homemade Liquid Lime-Sulfur, *F. H. Ballou*. Ohio Sta. Bul. 572 (1936), pp. 26 figs. 7. This paper is presented in two parts, (1) Stationary Equipment for Orchard Spraying, and (2) Home Making of Liquid Lime-Sulfur.

Under part 1 there are discussed the comparative merits of stationary and mobile spraying equipments, the locating of a stationary plant, and the planning, equipment, and operation of the stationary plant constructed at the Dale View test orchards. Some data are presented on the relative capacity and cost of operation of the two types of spraying equipment.

In part 2 there are presented a description of an experimental boiling plant and storage for homemade lime-sulfur and information on the preparation of the material. *(Continued on page 286)*

MEETING NATURE'S SCHEDULE

To the farmer, a calendar is more than a mere series of numbered days. It presents rather a parade of important jobs to be done, "weather permitting." From the day the first bit of soil has been cleanly turned, its moist, smooth contours glistening in the sun, until the shortening days bring the keen satisfaction of an ample harvest safely put away in bins, cribs and lofts or on the way to distant markets, the modern farm tractor is indispensable.

Conqueror of drudgery, saver of time, producer of dividends, the tractor by its versatility, is writing a splendid chapter in the inspiring epic of agriculture.

That the great tractor builders, whose products have traversed the seven seas, should have chosen French & Hecht steel tractor wheels for the permanent, safe mounting of their products is both a tribute to their own exacting standards and the exceptional strength and permanency of the lighter but STRONGER Tension-Bilt wheels we are privileged to manufacture for them.

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Air Tired Tractor Wheels

Most of the outstanding air tired farm tractors of today are mounted on these French & Hecht Drop Center Steel Wheels to accommodate pneumatic tires.

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•

Equipped with these wheels a tractor can go anywhere with ample traction under all conditions.

CONSULT WITH US—We invite all manufacturers of wheeled equipment to investigate the exceptional qualities inherent in Tension-Bilt steel wheels. They are stronger—they last longer—they cost no more.

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EXCLUSIVE WHEEL BUILDERS TO INDUSTRY SINCE 1888

Agricultural Engineering Digest

(Continued from page 284)

Blue Grama Grass for Erosion Control and Range Reseeding in the Great Plains and a Method of Obtaining Seed in Large Lots, *J. L. Fults*. U. S. Dept. Agr. Circ. 402 (1936), pp. 8, figs. 5. Harvesting trials with horse-drawn and motor-driven bluegrass seed strippers at North Platte, Nebr., in October 1934 and at O'Neill, Nebr., in August 1935 showed that these machines can be used economically to harvest tops of blue grama (*Bouteloua gracilis*). In threshing tests, seed with purities of 19 and 94 per cent was obtained from a bluegrass thresher at a cost of 79 cents a pound. Material harvested on a large scale was threshed most economically in an ordinary grain separator after certain adjustments were made, providing seed with purities of 15 and 24 per cent at a cost of 19 cents a pound. Pure seed with slight breakage was obtained when blue grama strippings were run through a hammer mill and subsequently cleaned in a fanning mill, but the hammer mill proved impracticable for large scale operations because of low daily output.

Measuring Fire Weather and Forest Inflammability, *H. T. Gisborne*. U. S. Dept. Agr. Circ. 398 (1936), pp. 59, figs. 16. Pointing out that the five principal causes of forest fire hazards, aside from human activities, are (1) the character and volume of forest fuels, (2) topography, which influences the exposure of the fuels and rate of spread of fire, (3) lightning, (4) wind, and (5) current moisture content of the fuels as determined by precipitation, temperature, humidity, solar radiation, and soil moisture, the author discusses various ways and means of measuring weather factors and inflammability. Among equipment, the construction and operation of which are considered, are rain gages, thermometers, thermographs, psychrometers, hygrographs, anemometers, wind direction instruments, and implements for determining fuel moisture. For integrating the effects of various factors there was designed a small cardboard device known as the Rocky Mountain fire danger meter. In a discussion of record keeping methods the author outlines correct use of cardboard report forms, the making of charts and tabluations, ways of localizing weather forecasts, the estimation of current hazards, and the making of fire danger comparisons.

A Cubic Volume Table for Eastern Red Cedar, *W. Maughan*. Jour. Forestry, 34 (1936), No. 8, pp. 777, 778. On the basis of measurements of 107 trees selected at random from 16 stands distributed on various soil types, the author presents a table for the eastern cedar (*Juniperus virginiana*).

Fertilizer Placement Studies with Cotton in Texas, 1935, *H. P. Smith*. Natl. Joint Com. Fert. Appl. Proc., 11 (1935), pp. 67-72; abs. in Texas Sta. Circ. 78 (1936), p. 24. This report extends that of the previous year. When fertilizer was placed 1, 2, and 3 in underneath cottonseed at the time of planting, slightly better stands were obtained for the 3-in placement and slightly better yields for the 2-in depth. Fertilizer placed 2.5 in to each side and 1, 2, and 3 in below the level of the seed gave results slightly in favor of the 2 and 3-in depths. Disturbing the soil under the seed at the time of planting retarded germination regardless of whether or not any fertilizer was applied.

Paints as Protective Coatings for Wood, *F. L. Browne*. Indus. and Engin. Chem., 28 (1936), No. 7, pp. 798-809. figs. 7. This is a brief statement presenting essentially the same information as in a previous report. (Continued on page 288)

Correction

In the paper entitled "A Lokator for Points on Land," by R. H. Denman, on page 201 of Agricultural Engineering for May, 1937, Fig. 1 (below) was inverted by error. Fig. 2 showed a border which failed to represent it as a card for field and office use. The lines of the scale run to the edge of the card for convenience in use, as shown here.

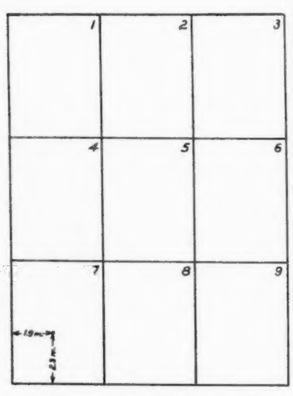
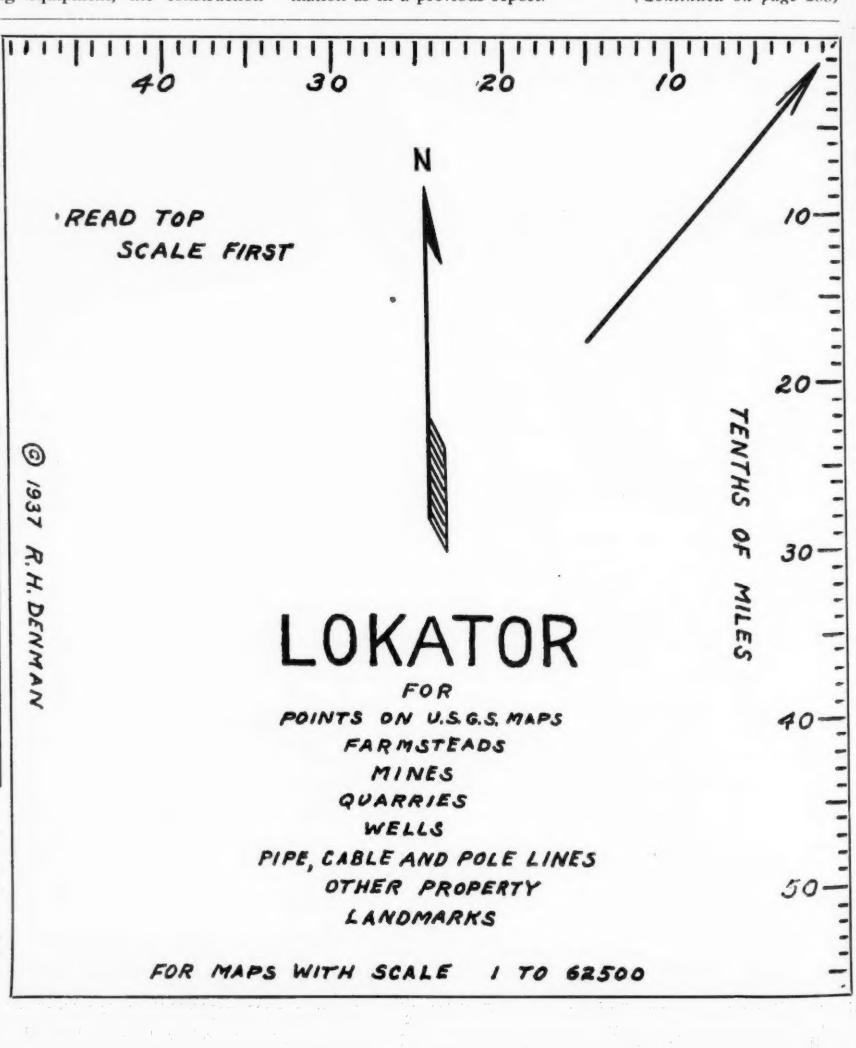
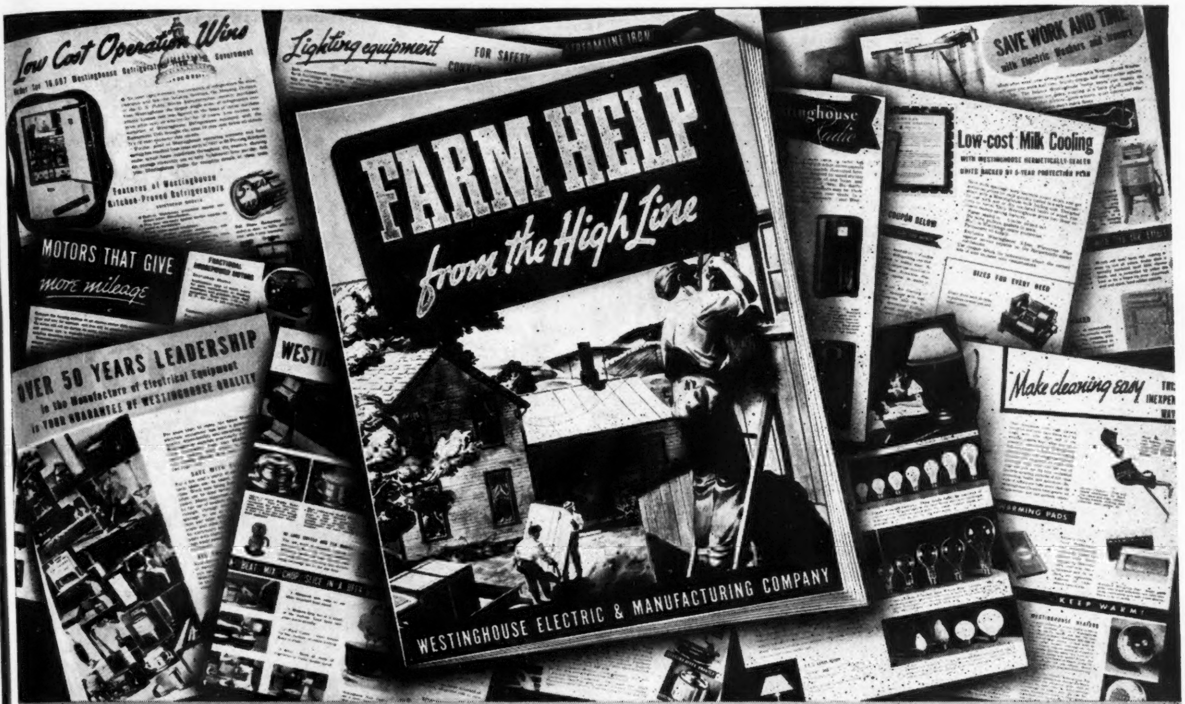


FIG. 1 (ABOVE) METHOD OF NUMBERING THE SECTIONS OF A USGS QUADRANGLE. A POINT MAY BE DESIGNATED BY ITS POSITION IN ONE OF THOSE SECTIONS, AS SHOWN

FIG. 2 (RIGHT) LOKATOR AS USED ON USGS TOPOGRAPHIC MAPS OF THE SCALE OF 1 TO 62,500





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ARTIFICIAL STORING OF GROUNDWATER BY SPREADING, *D. A. Lane.* Jour. Amer. Water Works Assoc., 28 (1936), No. 9, pp. 1240-1251, figs. 2. Various methods of storing ground water are described, it being pointed out that water spreading has a definite place in the water supply of the Southwest. Three general methods of spreading, practiced in southern California, are described, including the ditch or furrow method, the use of basins or ponds, and the use of wells or shafts.

Books Received

1937 BUYERS GUIDE, 5.75 x 8.5 in, 384 pages, paper bound, published by Farm Implement News, Chicago. A classified directory of the farm equipment industry, listing manufacturers of farm and garden implements, tractors, wagons and carriages, motor trucks, lighting plants, cream separators, gasoline engines, windmills, pumps, wire fencing and accessory lines sold by implement dealers. The main classification is of kinds or types of equipment. This is supplemented by an index to the classifications, an index to advertisers, a general directory of the U. S. manufacturers whose equipment is listed, by states and post offices, and a list of manufacturers by name, giving their addresses. Under each equipment classification all "orphan" makes still in use are listed, so far as known, with information as to whether or not repair parts are still available and, if so, the name and address of the source.

THE ELECTRIFICATION OF AGRICULTURE AND RURAL DISTRICTS, by E. W. Golding. Cloth bound, 6x9 in, XII+244 pages, 67 illustrations, indexed, English Universities Press, Ltd., Little Paul's House, Warwick Square E. C. 4, London, 16 shillings. This is one of a British electrical engineering series designed for use by both students and practicing engineers. The subject is divided into three parts covered by groups of chapters. Part I reviews the economic and social considerations of rural electrification in chapters headed "General Review," "Some Facts Relating to British Agriculture and Rural Districts," "Power Requirements on Farms and in Rural Districts," and "Development of Rural Electrification—The Present Situation." Part II covers "Electrification from the Point of View of the Farmer or Rural Consumer" in chapters on "Elementary Electrical Engineering," "Electricity for Lighting, Heating, and Domestic Purposes," "Application of Electricity in and Around Farm Buildings," and "Application to Horticultural Work." Part III applies to "Electrification from the Point of View of the Electrical Engineer," with chapters on "Farm Wiring" and "The Problem of Economic Supply to Rural Areas."

PROSPERITY BECKONS, *by William J. Hale.* Cloth bound, 5x7.5 in, II + 201 pages, no illustrations. The Stratford Company, $2.00. An economic and social outlook on the growth of chemistry as an applied science, and on its farm chemurgic possibilities in particular.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

ENGINEER who is familiar with agricultural equipment, particularly fruit grading and fruit handling equipment, is wanted by one of the larger manufacturers of such equipment. Anyone interested in this opening should write direct to Secretary, ASAE, St. Joseph, Michigan.

DESIGNERS and layout men familiar with grain, hay, and corn harvesting machinery wanted by a leading manufacturer of farm equipment. Must be high-grade men. PO - 115.

POSITIONS WANTED

AGRICULTURAL ENGINEER desires employment preferably in the educational field. Graduate of Clemson Agricultural and Mechanical College, and will receive master of science degree at the A. & M. College of Texas in June. In college work he has served as graduate assistant, teaching mostly farm machinery laboratory. Had three months' experience as assistant extension agricultural engineer with the South Carolina Extension Service. Single. Age 24. Available June 7, 1937. PW-275.